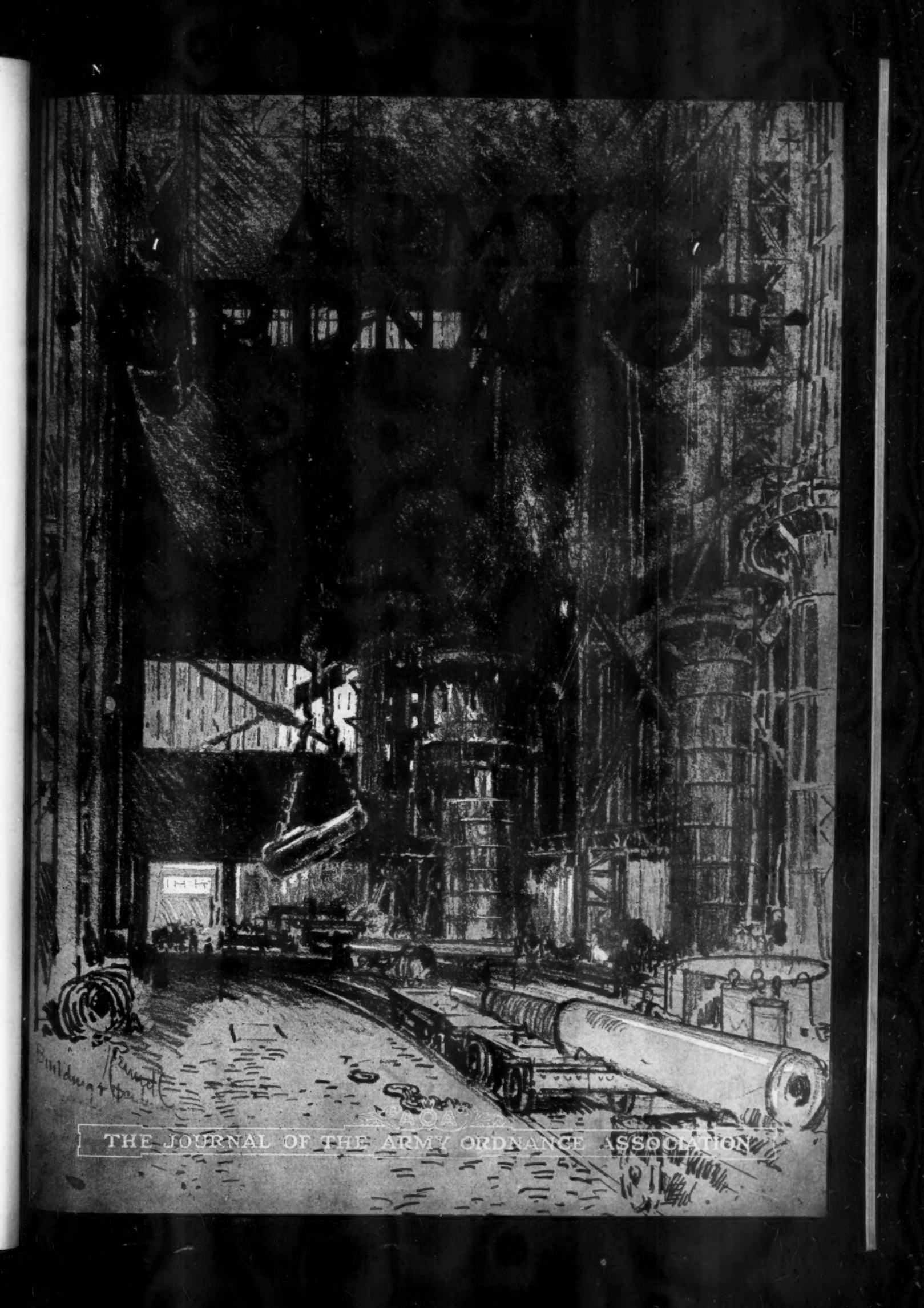
ORDNANCE
THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

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ARMY ORDNANCE

The Journal of the Army Ordnance Association

Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

Published by
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"When we consider that war brings with it an abnormal demand for commodities which range from foodstuffs, clothing and guns to automobiles and railway locomotives we realize the tremendous load that war places on industry and the vital dependence of military strategy on industrial effort. And this demand takes place when industry is least able to meet it—handicapped as it is by withdrawal of men for military service and by the necessity of adapting its factories to the production of articles with which they are possibly unfamiliar. And yet the additional load must be carried with as little interference with the needs of the civilian populations as possible."

Patrick J. Hurley, *The Assistant Secretary of War.*

The Eleventh Annual Meeting

OF THE

Army Ordnance Association

WILL BE HELD AT

The Aberdeen Proving Ground, Maryland

Thursday, October 10, 1929

THE FOLLOWING ORGANIZATIONS WILL PARTICIPATE:

THE NATIONAL AERONAUTIC ASSOCIATION

THE NATIONAL METAL TRADES ASSOCIATION

TENTATIVE PROGRAM

(DETAILED PROGRAM WILL BE DISTRIBUTED AT THE MEETING)

9:30 A. M.	Arrive Aberdeen Proving Ground.
10:00 A. M.	Main Front. Opening Exercises.
10:10 A. M.	Main Front. Gun Testing Division Firings.
10:40 A. M.	Main Front. Exhibition of Mechanized Force.
12:00 M.	Dinner.
1:00 P. M.	Administration Building. Meeting Army Ordnance Association—Presentation of Technical Papers and Addresses by Distinguished Guests.
1:40 P. M.	Main Front. Air Corps Demonstration.
2:45 P. M.	Seacoast Range. Demonstration—Antiaircraft Artillery.
3:45 P. M.	Seacoast Range. Demonstration—Seacoast Artillery.
4:25 P. M.	Aviation Field. Exhibition.
5:00 P. M.	Supper.
6:15 P. M.	Antiaircraft Range. Antiaircraft Artillery Night Firing.

Meals

Two kinds of meals will be available for guests. Special course dinner and supper served by caterer at the Service Club will be available for those who desire hot, served meals. The cost of these will be $2.25 for dinner (midday) and $1.75 for supper. Box lunches, served in cafeteria style, also will be available at midday and in the evening. These will consist of sandwiches, coffee, etc., and will be served from booths at the Main Front. The cost of box lunches will be $1.00 each. Due to the limited facilities at the Proving Ground and the necessity for guaranteeing in advance the meals to be provided, reservations should be sent without delay to the Commanding Officer, Aberdeen Proving Ground, Md., indicating the number and kind of meals desired. Breakfast need not be ordered in advance; it will be served a la carte by caterer for guests arriving on special trains. Reservations for meals, with check to cover, must reach the Proving Ground not later than October 7. It will not be practicable to refund for meals ordered. Make checks payable to Commanding Officer, Aberdeen Proving Ground.

RAILROAD ARRANGEMENTS

Reduced Railroad Fare

Members of the Army Ordnance Association, the National Aeronautic Association and the National Metal Trades Association can travel to the meeting at reduced fare by presenting an Identification Certificate to the local railroad ticket agent at practically any point in the United States. Certificates, with invitation and other data, have been sent to members of the Army Ordnance Association and participating organizations. A round-trip ticket to Aberdeen, Maryland, purchased under this plan will cost one and one-half times the one-way fare.

Special Train

A special train of Pullman sleeping cars open for occupany at 10 P. M. October 9, will leave Pennsylvania Station, New York City, shortly after midnight, October 9-10, arriving at Aberdeen Proving Ground for breakfast. Returning, this special train will leave the Proving Ground after the night demonstrations and will arrive in New York in time to make midnight connections for other points. Maj. P. R. Faymonville, Secretary, New York Post, Army Ordnance Association, 39 Whitehall Street, New York City, will purchase accommodations for those who desire to travel on this train.

A twelve-section drawing room sleeper will be run from Springfield, Mass., to Aberdeen Proving Ground and return, being carried on the special train from New York to Aberdeen Proving Ground and return.

The Springfield car will be attached to train No. 81, New York, New Haven and Hartford Railroad, leaving Springfield at 8:30 P. M., October 9. Stops to receive passengers will be made at Hartford, Berlin, Meriden, New Haven and Bridgeport. Returning this car will leave the Proving Ground with the special train for New York arriving at Springfield, Mass., about 8:54 A. M., October 11. Members and guests contemplating traveling in this car should communicate with Maj. J. K. Clement, Bridgeport District Ordnance Office, Springfield Armory, Springfield, Mass., for particulars.

Arrangements are contemplated whereby a special car will be operated for the meeting from Cleveland, Ohio, to Aberdeen Proving Ground and return. Those desiring to travel in this car should communicate with Maj. William A. Borden, Cleveland District Ordnance Office, 1524 Keith Building, Cleveland, Ohio.

Train Service

Trains as numbered will stop at Aberdeen on October 10, 1929. Consult latest time table for possible minor changes in time. Time shown is Eastern Standard.

GOING

Southbound	Pennsylvania Train No. 405	Baltimore and Ohio Train No. 15
Leave Philadelphia:		
Broad Street	7:20 A. M.	.....
West Philadelphia	7:25 A. M.	.....
Wayne Junction	.....	7:32 A. M.
24th & Chestnut	.....	7:50 A. M.
Leave Wilmington	8:05 A. M.	8:26 A. M.
Arrive Aberdeen	9:05 A. M.	9:17 A. M.

Northbound	Train No. 110	Train No. 518
Leave Washington	7:25 A. M.	7:35 A. M.
Leave Baltimore:		
Union Station	8:23 A. M.	.....
Camden Station	.....	8:23 A. M.
Mt. Royal Station	.....	8:29 A. M.
Arrive Aberdeen	9:00 A. M.	9:08 A. M.

RETURNING

Northbound	Train No. 134	Train No. 28
Leave Aberdeen	8:30 P. M.	8:33 P. M.
Arrive Wilmington	9:20 P. M.	9:20 P. M.
Arrive Philadelphia:		
West Philadelphia	10:00 P. M.	.....
Broad Street	10:05 P. M.	.....
24th and Chestnut	.....	9:55 P. M.
Arrive New York	12:25 A. M.	.....

Southbound	Train No. 127	Train No. 9
Leave Aberdeen	8:17 P. M.	8:10 P. M.
Arrive Baltimore:		
Mt. Royal Station	.....	8:56 P. M.
Camden Station	.....	9:01 P. M.
Union Station	8:55 P. M.	.....
Arrive Washington	9:50 P. M.	9:50 P. M.

ARMY ORDNANCE ASSOCIATION

Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

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Stockton, Calif.

THE Army Ordnance Association is a national organization of American citizens pledged to industrial preparedness for war as our Nation's strongest guarantee of peace.

THE Association endeavors to keep alive an interest in and knowledge of the design, production and maintenance of munitions. Other than a few manufacturing arsenals—six in all—there is no peace-time industry for the production of ordnance. Should war unhappily come again, industrial America will be called upon to produce munitions in great quantity and of intricate and unusual design. In an emergency time will not permit careful study or long preparation for the production of munitions. The problem is one of vital concern.

THE Army Ordnance Association believes that the solution of this problem, based on experience, lies in an active organization at all times coöperating with the Government. The principal objective of the Association is an active membership of American citizens, on whom the duty of design and production of munitions will fall in war, who will have an accurate and authentic knowledge of the complex requirements of ordnance. "Peace Insurance" in this form is the foremost aim of the Army Ordnance Association.

THE Association is purely patriotic; it has no commercial interests, no political alliances, and no religious affiliations. It is not operated for profit: its income is expended in furthering its aims. Its officers and directors serve without remuneration.

ARMY ORDNANCE, the journal of the Association, is published solely for the purpose of disseminating information on the progress of our munitions developments so that American industry may at all times know its responsibilities to the common defense.

The objectives of the Association as set forth in its Constitution are:

To assist in effecting industrial preparedness for war as being one of the Nation's strongest guarantees of peace;

To keep available the highly specialized knowledge necessary for arming the manhood of the Nation by stimulating interest in the design and production of ordnance material;

To promote mutual understanding and to effect cooperation with American Scientists, Inventors, Engineers and Manufacturers in civil life and the Regular and Reserve Officers of the Army Ordnance Department;

To provide, when required, the services of competent committees to investigate and report upon special ordnance subjects;

To assist in developing and maintaining an efficient personnel, both commissioned and enlisted, for the units required for Ordnance Field Service in the event of an emergency;

To commemorate the services rendered by the Industry of the Nation and by the Officers and Civilian Employees of the Ordnance Department in the wars in which the United States has been engaged.

ARMY ORDNANCE ASSOCIATION
The Mills Building, Pennsylvania Ave. at 17th St., N. W.
Washington, D. C.

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Patrick Jay Hurley

The Assistant Secretary of War in Charge of Industrial Mobilization

BORN at Choctaw Nation, Indian Territory (now Oklahoma); A. B. Indian University, Bacone, Indian Territory, 1905; LL.B. National University Law School, Washington, D. C. 1908; admitted to Oklahoma Bar, 1908; admitted to practice before Supreme Court of the United States, 1912; Attorney for Choctaw Nation, 1912-1917; President First Trust and Savings Bank, Tulsa, Oklahoma, since 1927. Captain Cavalry, Indian Territory Volunteer Militia, 1902-1907; Captain Oklahoma National Guard, 1914-1917; Major and Lieut. Col. World War; participated in Aisne-Marne, Meuse-Argonne, and St. Mihiel offensives and defensive sector operations of A. E. F.; negotiated agreement between Grand Duchy of Luxemburg and A. E. F., 1919. Distinguished Service Medal and other World War citations in general orders for gallantry in action.

ARMY ORDNANCE

VOL. X SEPTEMBER-OCTOBER, 1929 No. 56

New Ordnance for Old

The Need for Actual Production of Modern American Munitions

By Benedict Crowell*

I PROPOSE to take this means of placing before the readers of ARMY ORDNANCE a few thoughts concerning American munitions of today. I dare say that few if any students of modern armament will doubt that our munitions developments of the post-war period are epochal and this in spite of a dwindling interest in the subject generally. The fact is—and to my mind it is an amazing fact—munitions development has not been confined to any one class of military armament but, on the contrary, has embraced every kind and classification of what we term ordnance.

In what I shall say here I have ordnance primarily in mind. Munitions, of course, is an all inclusive term since it embraces not only fighting equipment, large and small, but also the stores and provisions required by a fighting force. Thus, in a broad sense, the term runs the entire gamut from the huge railway gun to a chocolate bar, if you please, or a package of cigarettes. In the matters I am now discussing, however, I exclude from consideration the chocolate bars and cigarettes, clothing and equipage, and confine myself to ordnance, that is, guns and their mounts, fighting vehicles such as the tank, ammunition and explosives, eliminating aircraft and naval armament—not because they are unimportant, but my subject is already broad, and I had rather discuss one salient idea than attempt to treat of many.

MY thesis is this: We have developed in America since the World War markedly superior ordnance of every kind and classification. So successful has this development been that American ordnance today is acclaimed, by those who know, to be the equal of that of any other nation and, no doubt, vastly superior to that of many. But we have not been able to produce more than a few—more than a half dozen is an exception—of any major type. It is high time, as I see it, that we launch upon a real manufacturing program of limited rearmament first to enable our Regular Army to become familiar with the new types; secondly, to permit the civilian components of the Army, the National Guard and Organized Reserves, to become acquainted with modern weapons; and thirdly to enable our arsenals and commercial plants to understand the complicated manufacturing processes involved.

That American post-war ordnance is all that I claim for it needs no proof. Reference to particular developments may be pertinent. Take the 75-mm. field gun, efficient weapon though that old stand-by the French 75 is, the American gun of the same caliber today is claimed to be far more potent. The range of the French gun with which American forces were armed in the World War is doubled by the new American 75. In the design of the carriage and other parts many improvements have been made. I believe I am safe in saying that not a half dozen of the American guns have been built. Even our own arsenals have had little experience in their fabrication. Our commercial establishments—upon which we must depend in war—have produced none. Again, take our antiaircraft guns. They are vastly superior to any World War types. Their range, accuracy and mobility are beyond all comparison with the older models. If the American Army has four complete batteries—four guns to the battery—I am in error. But I believe I have overestimated the number considerably. And so I might cite practically every major item of defensive fighting equipment. We have the designs and pilot models but we have virtually none of the weapons themselves.

TO my mind this state of affairs is extremely serious. I have no intention to appear as an alarmist, neither would I want the reader to infer that I am preaching a war scare. Both roles are farthest from my purpose. But we may as well be practical and look at things as they are. Our Army, if it is to function at all, must be munitioned with the latest and best equipment possible. The Ordnance Department of the Army under the leadership of a capable engineer and executive of many years' experience, Maj. Gen. C. C. Williams, has performed the engineering work required and has produced exceptional pilot models of all classes. Our Army should have sufficient of the new equipment, if not to arm a majority of its active units, at least enough to train a goodly portion of our officers and men in the tactical use and maneuver of these newer types. I venture to say that the greater part of our Army personnel never has laid eyes on many of these new types. Little wonder then that an Army officer when asked by a civilian as to the method of opening and closing a breech block on a new type gun was unable to handle it. It is little enough to ask that our Regular Army have sufficient of the new standard types to become familiar with their use.

Likewise the civilian components of the Army should train with the new equipment. Let us take as a case in point the new antiaircraft equipment. We have many active A. A. units of the National Guard holding their regular drills and tactical lesson periods throughout the year and their annual training encampment during the summer months. It must be that they are using the obsolete types of equipment because there are none of the newer types available for them. The tactics of the new weapons are not those of the old. Their servicing is far different. Their

*President, Army Ordnance Association. The Assistant Secretary of War and Director of Munitions, 1917-1920.

possibilities are far greater. Indeed, it is pertinent to ask: Why train with and study the peculiarities of obsolete types when, if there is another war, decisive battles may be fought and decided with the most up-to-date weapons. Hence, it would seem that our regular and reserve fighting forces are training under a severe and rather useless handicap.

THERE is another phase of the question that must be apparent to thinking men. We have in America a system of national defense that is predicated largely upon the civilian soldier and the civilian engineer and manufacturer. All readers of Army Ordnance are familiar with the strictly military aspects of the reserve man power phase; i. e., our National Guard and Organized Reserves. Present policies and plans are so sensible and are receiving such practical application as, in my judgment, to make the man-power aspect of our preparedness plans self-sufficient. Granted that our requirements for men for some years to come will be what they are today and granted too, that present policies will continue, man power for the defense of America is a settled question. It is the availability of sufficient trained munitions power for another emergency which should give us real concern. By and large, we have in America the greatest engineering and manufacturing capacity in the world. Keeping that capacity trained and ready with a minimum of delay for the production of munitions in war is, as I see it, the most important defense activity before us. Our system of procurement is good. Our plans for munitions manufacture are excellent. With the country divided into fourteen territorial districts under the leadership of skilled industrial leaders, whose duty it is to allocate war-time munitions manufacturing requirements to commercial plants best equipped to undertake the work, our Army system of industrial preparedness is in actual peace-time operation. However, it is one thing to make plans on paper and another to keep those plans fool-proof and workable. Manufacturers may have the best of intentions, their engineers may understand specifications from A to Z, their foremen and machinists may be of the highest skill, yet it is a truism to say that there is many a loophole in the best of plans. Only actual trial will remove the pitfalls.

Therefore I return to the new armament situation and suggest that the demand for sufficient quantities of the new types in the hands of our Regular Army and civilian reserves is synonymous with the demand that American industry be given at least a piecemeal opportunity to produce a limited quantity of the new types. Obviously our arsenals must be included since already, and for some years now, they have been operating on a very uneconomical basis with sufficient work to utilize only a fraction of their capacity. Hence a program of rearmament would provide the new matériel for the Army and at the same time would enable the arsenals to operate under economical conditions. Such a program also would permit selected manufacturers throughout the country to undertake actual manufacture of small quantities of the munitions they must produce in war.

AS an interested civilian I recommend such an idea to your consideration. I do so with the full realization that steps are already under way in the War Department for what is known as a program of limited rearmament. From what I have learned of it, that program is entirely too modest. It proposes, so I am told, to provide rearmament for approximately ten regiments during the next ten years. I hesitate to calculate under such a rate when, if ever, the task would be completed. I believe that the program should be more comprehensive, its annual rearmament rate should be considerably higher.

This naturally introduces the element of cost. I am not in a position to discuss details. This much I know, as a nation we are not spending enough for our munitions program. During the World War we were spending at the rate of a million dollars an hour on munitions and we were not able to catch up with the loss of time in the early stages of the war. Is it not better to spend wisely in peace to secure a well-rounded munitions program than to spend unwisely in war to reach a goal that is practically unattainable? Parsimony has its limitations no less than extravagance. Moreover, the cost of wise preparedness is not disproportionate. If we are to have a defensive system at all it must be as complete and as fool-proof as it can be made. Our War Department realizes this fully. It is doing well with the limitations the people themselves have imposed. That the people may realize the seriousness of the situation, that they may know the importance of replacing our new guns with old for the better training of the Army and the more complete education of industrial America, that they may come to know that a penny spent during peace may be a dollar—or even a priceless life—saved in war, these are matters which demand frank discussion and sympathetic action. I am confident that they are worthy of the serious thought of the members of the Army Ordnance Association and of all other citizens who are interested in national defense.

California Post, A.O.A., to Hold Annual Meeting at Benicia Arsenal

THE annual meeting of the California Post, Army Ordnance Association, to be held at the Benicia Arsenal, Benicia, California, Thursday, September 19, 1929, will have all the indications of a miniature Ordnance Day at Aberdeen. Members of the California Post and their friends will be the guests of Maj. George F. Lemon, Commanding Officer of Benicia, who has invited also members of the San Francisco Sections of the American Society of Mechanical Engineers, The American Institute of Electrical Engineers, The Institute of Radio Engineers and The Signal Corps Association.

With the demonstrations at the annual Aberdeen meetings of the Army Ordnance Association as a model, Major Lemon has arranged an unusually interesting program of exhibits. Through the courtesy of the superintendent of the Army Transport Service at Fort Mason, California, transportation will be provided from Fort Mason to Benicia. The return journey will be made by boat. Mr. Pliny E. Holt, President of the California Post, A. O. A., and Maj. M. L. Brett, Secretary, are arranging what is planned to be one of the most noteworthy munitions preparedness meetings on the West Coast.

America First in the Air

The Purposes of the National Aeronautic Association

By Hiram Bingham*

THE National Aeronautic Association was formed in Detroit in 1922, in answer to the need for a representative organization to foster and encourage the development of American aeronautics in all its phases. The task undertaken by those pioneers was a large one, in view of the general apathy exhibited at that time by the public toward flying. Nevertheless, the original group and those succeeding the original organization have clung tenaciously to their purpose, and it is a source of great satisfaction to them to know that there are thousands of licensed pilots and thousands of airplanes in this country today; that air transport lines and air mail routes cover the Nation; that the military and naval services are equipped with modern planes and engines in almost every particular; that airports are being dedicated almost daily, and that it no longer is a news event when someone makes a flight.

Harris & Ewing

U. S. Senator Hiram Bingham, President, National Aeronautic Association.

Prior to the formation of the National Aeronautic Association, and aside from local aero clubs and purely technical societies, there had been only two attempts to establish national membership in aeronautical organizations. The first and oldest of these attempts was the Aero Club of America, which was founded and fostered during its successful years by a group of wealthy sportsmen, and the other was the American Flying Club, which was formed shortly after the Armistice and whose membership consisted chiefly of former service pilots. Neither of these was entirely satisfactory. So a new organization was formed under the banner, "America First In the Air."

America is the birthplace of human flight, and America always should be supreme in the science, art, profession and adaptation of this twentieth-century boon. As is the case with everything new, there are some who are quick to realize its possibilities, while others, through long association and satisfaction with the older things, do not feel justified in giving up the established order for an innovation.

Prior to and during the World War, areonauties developed a following of men who stayed with the infant science through adversity and in the face of discouragement and distrust. Why? Because they had flown—they had traveled through those fluid lanes of transportation above the earth which the birds for centuries have monopolized while man sat by enviously. The fact that human beings could rise off the earth, fly through the air, enjoy magnificent views, and land at a destination in shorter time than any other available means of transportation could provide, was the incentive to remain loyal to aeronauties.

SINCE the war the principle has been the same—fly with the birds. Labor, time, money and ingenuity have made this principle more practical and increasingly reliable each day. Some of us who learned to fly on machines of the vintage of 1916-1917 would deliberate a long time before going aloft today and performing in exact replicas of those planes. This is because there have been enormous strides in the technical development of aireraft. The war and pre-war pilot, viewing the modern commercial and military aireraft of today, is in a better position than anyone else to appreciate the phenomenal development of aeronauties.

While the engineers, technicians and manufacturers strive to turn out better equipment, the National Aeronautic Association has what may be considered the more difficult task of persuading the people who have clung to the earth to take to the air. The object behind this effort of the Association is to place within the reach of the people the magic carpet which has the power to convey them and their products from one place to another at an astounding rate of speed. When the entire Nation takes advantage of this opportunity the economic benefits will react favorably to every man, woman and child. Just as air transportation will prove to be a power and influence in the commercial world, so will it be a power and influence in the defense of the Nation. Aircraft, after all, are vehicles for transportation —transportation of people, mail, express, and freight, or transportation of bombs, poison gas, machine guns and other instruments of warfare. But aireraft are superior to any other vehicle in existence today because of their speed and their ability to travel in straight lines between points, uninterrupted by other vehicular traffic.

*U. S. Senator from Connecticut. President, National Aeronautic Association.

The strength of the National Aeronautic Association lies in the work of its members and chapters in the field. Headquarters is a clearing house, or a central point of assistance and coördination for the work of the various chapters and members not affiliated with the chapters.

When a chapter is organized in a city or town its first object is to create and develop the aeronautical interest in that particular area. There probably will be need for establishing or improving an airport or landing field, and after this is accomplished, efforts are directed towards making this investment pay by attracting air traffic in the form of air mail and air passenger routes, and by promoting local flying services for sightseeing flights, air taxi work, aerial advertising, aerial photography and such other activities as the commercial world has developed through the medium of the airplane. Eventually that particular town with an active chapter takes its place on the aeronautical map of the country, its facilities for flying become known among pilots of the land and local business is stimulated.

Through the chapters, the individual members of the N. A. A. have the opportunity of giving voice to problems of local and national importance that will be heard more readily and command more respect than if they are uttered in an individual, isolated capacity. At the annual convention of the N. A. A., held each year in conjunction with the annual air races, chapter delegates are entitled to votes and members are invited to participate in the proceedings.

THE most important activity in which the Association is now engaged involves the establishment of private flying clubs under the N. A. A. plan.

Sincerely believing that the establishment of private flying clubs constitutes the backbone, the life-blood and the inspiration for civil flying in this country, Porter Adams, as President of the Association, on February 20, 1928, appointed a committee "to study the possibilities of organizing private flying clubs on a national scale and through the N. A. A. as a national coördinating body." Mr. Edward P. Warner, former Assistant Secretary of the Navy for Aeronautics was named chairman of this committee, and the Assistant Secretary of Commerce for Aeronautics, William P. MacCracken, Jr., and Dr. George W. Lewis, Director of Research, of the National Advisory Committee for Aeronautics, members.

The study behind the plan to establish flying clubs throughout the Nation under the leadership and guardianship of the Association included trips to Europe and Canada where light plane clubs are thriving under government subsidy, and also a careful survey of the flying club situation in the United States.

A plan was drawn up with the view to rendering all possible assistance to those groups throughout the chapters of the Association desirous of creating flying clubs on a firm foundation, and also of creating interest in communities where no steps along this line had been taken. But to carry out this plan with the greatest results funds were needed. This problem was soon solved.

The Daniel Guggenheim Fund for the Promotion of Aeronautics, Inc., came to the assistance of the plan with a grant of $12,000, which will make it possible for the N. A. A. Flying Club plan to be carried to the farthest corners of the United States.

THERE are hundreds of persons throughout the United States who know how to fly, yet they cannot afford to purchase a plane and maintain it. There are hundreds of others now learning to fly who, upon completion of their courses, will be forced to return to earth again through lack of funds to rent or purchase a plane to build up time. There are still hundreds of others who want to fly but are prevented from taking courses of instruction through physical disability, lack of time, or lack of the necessary tuition.

These, and many other groups, will be served to advantage by the private flying club. For a reasonable sum, an individual can become part owner of a plane and have his appetite for flying satisfied in the course of his year's dues. Above all, the plane is protected by insurance, and there also is protection for the club members against property damage, public liability and passenger liability.

The National Aeronautic Associaton feels that at the present stage of aeronautic growth, the flying club plan it launches is the best obtainable anywhere. It also believes that no group of persons forming a club outside of the N. A. A. plan can obtain the same protection and benefits, as the N. A. A. clubs will operate under uniform rules and regulations which bear the approval and endorsement of the insurance companies.

Through the N. A. A. plan opportunity is offered to America to develop wings. This opportunity should not go unanswered.

THE Association is the exclusive representative in the United States of the Federation Aeronautique Internationale, the world-governing body for aircraft performances. American pilots desiring to undertake the establishment of new world records must abide by the rules and regulations of the Contest Committee of the Association. This feature of the Association's activities has enabled American aviation to progress from the material and technical standpoint. These record attempts are of the greatest value because they encourage competition and are a direct impetus for the constant refinement and improvement of aircraft.

The Contest Committee, which carries out the rules and regulations of the F. A. I., has established a plan of decentralization of its national activities so that active chapters in communities where record trials are frequent may take over the duties of certifying record flights. This important work naturally stimulates interest, particularly in view of the fact that aeronautical history is established with the aid of the local chapter in particular. These activities are not confined entirely to record attempts, for the local chapter may be delegated to conduct an aeronautical meet which has been sanctioned by the national committee. Outstanding among the record-breaking trials supervised by local chapters was the flight of the Army Fokker monoplane "Question Mark" in California, and the monoplane "Fort Worth."

In the proper conduct of this contest work the local chapter includes in its membership a timer, certified and

officially designated as such by the F. A. I. in Paris. It also must be in possession of barographs for record-making purposes, an official F. A. I. stop-watch, and other equipment necessary to record, accurately, airplanes in flight competition. An additional important duty is the surveying of courses for competing planes to fly over.

In order that the rules and regulations of the F. A. I. and the N. A. A. may be properly enforced, another function of the chapter is to appoint a committee whose duty it is to see that these regulations are not violated by pilots holding the F. A. I. certificate and the annual sporting license of the N. A. A. In the event that violations are noted, the committee is in a position to report them to headquarters and see that the penalties are carried out.

Harris & Ewing

Porter Adams, Chairman, Executive Committee, National Aeronautic Association

In return for part of the dues, each member of the N. A. A. receives THE AERONAUTIC REVIEW, which is the official monthly publication of the Association. This magazine endeavors to record all the activities of the chapters from month to month, thereby allowing a full share of recognition to each local organization for its efforts on behalf of aviation development in its community. However, this is a secondary feature, as the prime object is to disseminate authentic information on the latest phases of aeronautics, prepared by persons of authority and well-known in the aeronautical world. Through this magazine each member, whether affiliated with a chapter or not, has an opportunity to give expression to his views on problems concerning aeronautics. Each voice is heard not only by the entire membership but by the directing heads of the industry and the Government.

THE program of the National Aeronautic Association for the present year as drawn upon with the coöperation of the Advisory Board and approved by the Board of Governors follows:

"We favor:

"1. Adequate and thorough training for civilian pilots, not only as a protection to the new pilot, but also to make him of potential value in the defense of the nation.

"2. The energetic development of the activities of organized reserve aviation in the Army and Navy with liberal provision of airplanes for the reserves and of supplies for maintenance and operation.

"3. The formation of private flying clubs by the various chapters of the N. A. A.

"4. The continuation and perfection of an industrial war plan system whereby the various manufacturers of aircraft will be able on short notice to supply equipment for military or naval purposes in time of need.

"5. The enactment of uniform state aeronautical legislation, which should include provisions making it mandatory for all pilots and aircraft engaged in commercial activities to carry Federal licenses.

"6. The maintenance by the Federal Government of an adequate network of meteorological stations, personnel and equipment, under a central organization, for the purpose of furnishing weather advices and information so that pilots may never lack adequate information as to weather conditions ahead along any of the commercial airways, and to insure for national needs in times of emergency.

"7. The enactment by the Congress of the United States of legislation which will correct the injustices wrought against the personnel of the Army Air Corps.

"8. Participation in such aircraft competitions of an international character as will maintain this country's prestige in aeronautical affairs and at the same time enable it to profit from the technical knowledge such competitions produce.

"9. Urging upon every community in the United States the importance both nationally and locally of the establishment of adequate air navigation facilities, particularly landing fields and, wherever feasible, airports, in their vicinity.

"10. The development of rigid airships for the purposes of transoceanic and intercontinental travel as well as for naval purposes.

"11. The encouragement of American aircraft markets in foreign countries.

"12. The prompt construction for the United States Navy of additional aircraft carriers to the number of at least three in the next two years, with the object of fully developing the technical and tactical possibilities of that type of naval vessel.

"13. The completion of the five-year aircraft programs for the Army and Navy as scheduled by Congress, with such amplification from time to time as may be required to meet the needs of the national defense.

"14. The continued expansion of the air mail system and its use, and further, the development of commercial air mail lines to the countries of Central and South America.

"15. A model airport for the Nation's Capital at Gravelly Point."

THE National Aeronautic Association is the most representative body of aeronautical thought and activity in this country. A member of the Association has the satisfaction of knowing that he is working side by side with the foremost leaders in aeronautics, who constitute its officers, advisory board, board of governors and committees. They give their time willingly and without compensation, solely for the purpose of seeing that America does not lag behind other nations in the art and science which was born in this country just a little more than a quarter of a century ago.

The officers of the N. A. A. are as follows: Roscoe Vaughan, of Kansas, vice-president; B. F. Castle, of New York, treasurer; Valentine Gephart, of Washington, secretary, and Frederick R. Neely, general manager. National headquarters are in the Barr Building, Washington, D. C.

Mechanization and Realization

Emphasizing the Three Main Factors of Tank Specification

By J. F. C. Fuller*

AT the opening of the last century, Richard Trevithick (1771-1833) invented his "portable steam engine," and on its first crude advertisement he printed—"Catch me who can. . . . Mechanical Power subduing Animal Speed." It was a tremendous idea, unproven, and yet an idea which now, a hundred years after his day, demands no proof, because it has grown into a self-evident fact. Had he, in 1801, stated that, within a hundred years of that date, his "Puffing Devil," as it was sometimes called, would revolutionize land transport, no one would have listened to him, and yet were he today to return to this world and prove that he was right in this prediction, his reception would not be a very noisy one. The truth is, that today it is as difficult to realize what the world would be like without the locomotive as it then was to realize what it would be like with it. One day, I am of opinion, and at no very distant date, military mechanization with all that it means will similarly pass from the footing of a postulate to that of an axiom.

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Company of 4 Rolls-Royce Armored Cars of Latest Type on the March at Salisbury Plain, England.

In 1918 the World War was won by motorized weapons and vehicles: by warships, by aëroplanes, by tanks, locomotives and lorries. It was won by militarized science and industry, and it was not won by fighting man-power, which dismally failed to accomplish its end in the earlier stages of the war. Immediately peace was concluded, like a scattered mosiac, the picture of the winning of the war was lost, few parts of the grand panorama actually disappeared, but each part became separated from the rest, and so completely separated that, were it possible for another great war to be declared today, every country except England would enter that war as blind to its reality as they were blind to the reality of 1914.

That I have excepted my own country may seem presumptious, but I am sufficiently well acquainted with the progress of military organization on both sides of the Atlantic to know that this presumption is a fact, which though it may be quibbled at and criticized, cannot logically be refuted. In 1919 there were not a dozen soldiers of any note in the British Army who supported mechanization, and as late as the autumn of 1927—that is, less than two years ago—an English general officer commanding-in-chief, and therefore an exalted personage, could still say: "Now, we have heard a great deal about the infantry being helpless in face of these tank attacks. My personal opinion from what I have seen is that it is not so at all, and I think with the improvement of antitank weapons and practice in quick dispersion, it is still less likely to be true. I hope no infantry officer thinks it. I have no doubt that infantry will learn to meet an attack by tanks with the same confidence that they learned to meet an attack by cavalry and the *arme blanche*." Today, no subaltern officer in England, I will not yet say in the British Empire, could deliver himself of such claptrap, and the reason for this remarkable change of outlook is that the seed which was sown by a few enthusiasts in the years immediately following the war is only just beginning to show above the military soil. It has taken, approximately, ten years to germinate in a very fertile soil, that of a highly-industrialized country and what is equally important a non-agricultural one. It is not because the English army is today in possession of large numbers of tanks, aëroplanes and armored cars, that this army stands apart from all other armies, but because the bulk of English soldiers have accepted what I will call the "tank idea." Change of mental attitude has been the true battle, and it has been won. Ten years ago we had more tanks than we have today and we were an obsolete army; today we have far more ideas than tanks and we are a progressive army. Ten years ago, and I say this in all modesty, for no effort on my part could have been successful unless circumstances had been propitious, I launched a campaign based on a most self-evident text, which was: "Half an inch of steel will stop half an ounce of lead," and today its truth is being realized.

IN February, 1921, a cavalry colonel, weighing about eighteen stone, in an article appropriately entitled "Substance and Shadow" wrote of me as follows: "It would be as well to remind those adherents of Colonel Fuller, to whom his romantic prognostications may appeal, that Cavalry

*Brigadier, British Army. In command of a Brigade at Wiesbaden, Germany.

officers with whom he associates the term 'mental inertia' compared favourably with the officers of any other arm in the late War . . . the majority of Cavalry officers went into the War having less to learn from a professional point of view than their comrades in any other branch of the Service." (If not an overwise, surely a courageous statement, seeing that in 1914 cavalry as cavalry were much as they were in the days of Rameses II). "In conclusion," he exclaimed, "the calvary will never be scrapped to make room for the tanks. . . .The stodgy-minded Britisher, as they call him, does not mean to catch at the shadows and lose the substance."

Here was an opponent of prognostications prognosticating in his turn, and what was the value of his forecast? Eight years later the Army Council, the brain of the British Army, issued the first manual published in any army on the new tactics, under the title of "Mechanized and Armoured Formations," and in it, amongst other things, may be found the following:

"At the present time an open and flexible mind is, therefore, one of the first qualifications of an officer."

"By increased mobility the art of generalship is enhanced."

"In favourable country the mobility conferred by mechanization is greater than has ever been attained by mounted troops."

"Some cavalry will be required for close reconnaissance in front of the infantry, unless the latter are carried in mechanical transport and equipped with mechanical 1st line transport, in which case light tanks will take the place of the divisional cavalry regiment."

Such a manual, had it been published ten years ago, would have been of little value because it would have met with a hostile reception. Today it is welcomed, for the mental outlook of the officer and the soldier has changed, a change due to propaganda and force of circumstances—the general introduction of the motor car. But a few months back I overheard my soldier servant say to my groom: "Of course we cannot do away with infantry altogether, but speed in war is everything." When the private soldier talks like this, a manual, such as the one in question, becomes valuable; but as long as generals-in-chief can compare tanks to lancers, however good the manual may be it must remain valueless—a book and not a Bible. Today in the British army we have a new tactical testament, because we are the believers in a new military gospel, and it is the gospel which has created the book—the belief of the soldier in the newest arms which science and industry have rendered possible. Any foreign army can copy this book, but none can make full use of it, or any like it, unless its soldiers believe in its tenets. To a Buddhist the Bible is a literary curiosity, to a Christian it is an inspired work, and no military manual is of the slightest use unless it is inspired, not so much by the thoughts of those who wrote it as by the faith of those who read it. It is for this reason that I believe that the British army is at the present moment some ten years in advance of any continental army, indeed a unique situation, seeing that our first line of defense remains our fleet.

BY this I do not mean that we are far advanced in thought, but that we are at a certain distance, and a measurable one, from former thought. That a bullet can be stopped by a steel plate has become obvious, but that this single fact will in time revolutionize tactics is as yet far from being fully realized, because, curious as it may seem, very few soldiers and still fewer civilians have realized, or do realize, that the focal or key problem in modern tactics is how to deprive the bullet of its power, and obviously the simplest solution is to cut short its flight. In order to grasp what this revolution entails let the reader picture to himself a battle in which no bullet fired caused either death or injury.

Since the discovery of gunpowder and the consequent introduction of firearms there have been two great tactical epochs, and today we are entering a third. The first was that of the musket, the second of the rifle, and today the third is that of the gun or cannon. In the first the central idea was that the musket supported by guns at very close range should assist forward the pike, and that a clinch between the opposing infantry should take place, under cover of which the opposing cavalry could manoeuvre against the flanks and rear of the clinched masses of foot soldiers. All four arms, musket, pike, gun and lance closely coöperated in the overthrow of the enemy.

The invention of the bayonet, which amalgamated pike and musket, had a profound influence on tactical formation, as it enabled the solid and hollow squares of the sixteenth and seventeenth centuries to be replaced by comparatively shallow lines of men, it also enabled the foot soldier more effectively to protect himself against calvary, in fact, the power of cavalry definitely declined soon after its introduction. During this period the tactical idea was a twofold one: first to produce a longer line of men than the enemy's so that his flanks could be overlapped, because cavalry could no longer so readily attack them, and secondly to gain superiority of fire in order to assault, after which it was left to the cavalry to pursue the fragments.

The changes begun by the bayonet were continued by the rifle, and the first great rifle war was the Civil War in America which introduced the second tactical epoch. In this war cavalry, as a combatant arm, disappear from most of the battlefields because they cannot face the rifle and the bayonet. Artillery is driven back, for the guns can no longer come into action with the infantry, they must get behind them, and not being able to use indirect laying they are frequently useless. Battles now are mainly infantry engagements in which the problem is one of numbers of men and weight of lead. Assaults are the order of the day, and seven out of every eight fail. An obsession for masses of men obliterates the fact that it is weapons and not men who give blows. The value of the breech-loading rifle is not realized. General Alexander, who commanded the Confederate artillery at Gettysburg, writes: "There is reason to believe that had the Federal infantry been armed from the first with even the breech-loaders available in 1861 the war would have been terminated within a year." With the Spencer magazine rifle it is the same, its effect is terrible and yet not understood except by the immediate participants. Of this weapon the Federal General James H. Wilson says: "I never knew a well-directed assault by troops armed with Spencers to fail, nor have I ever seen any line that could stand before seven successive discharges of Spencer carbines." This is true enough when the defender is armed with a muzzle-loading rifle, but arm him with the same weapon and every assault will fail. In 1870

this was definitely proved when breech-loader met breech-loader, for no single frontal attack made by French or Prussians succeeded in its object. The clearest fact was that mechanical genius had so enhanced bullet power that the rifle on the defensive could scorn the rifle in the attack. If a front could not be turned to all intents and purposes it was invulnerable, and for all who cared to see, this was proved in the battles and combats of the South African War (1899-1902) and the Russo-Japanese War (1904-1905), neither of which was won by a tactical decision; both of which petered out by the exhaustion of one of the opposing sides.

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New Guy-Vickers British Armored Car Developed for Use in India.

Whilst the bullet was utterly changing tactics, the locomotive and the steamship were vastly modifying strategy. At sea everything changed except tactical ideas, which in the navies of the world up to 1916 remained to all intents and purposes those of sailing-ship days. On land the change was almost as remarkable, the size of armies grew and grew until the general staffs thought in terms of millions of men in place of hundreds of thousands, and so obsessed were they by these astronomical figures that their one problem became that of human tonnage—one ton of men would crush half a ton, therefore a million tons would crush France, Germany, or Europe. Such was the tactical theory, mainly Prussian in origin, which controlled military thought before the World War, and which was rendered possible through the carrying power of the railroad, and which within six weeks of the outbreak of the war proved itself to be utterly fallacious for every attack was wrecked by the bullet.

THE whole of this period, that is from 1861 to 1914, is one of the most interesting in the whole history of war, because the tactical idea which controlled it was one which assumed that soldiers themselves could be mechanized, that is that men could be turned into machines. The soldier was looked upon by the military designers as a self-propelled gun mounting, or mobile bipod, upon which was to be fixed a rifle. Steam-power had produced the rifle, it had also produced the locomotive which enabled masses of men to be moved and assembled, but it had not produced the man himself. This was the one point the strategists and tacticians had overlooked, when in the quietude of their studies and lecture rooms they had moved imaginary masses over their maps, forgetting that their flagged pins and little blocks of coloured lead were soulless things, and that in order to perfect, and even render possible, their destructive machines—their armies—it was imperative that they should protect the man, who as a soldier on the battlefield always prefers to live than to die.

Discipline, esprit de corps, patriotism, fear of punishment were to drive the men forward like steam-power behind a mechanical drill, and in order to reduce casualties artillery was to support the attack whilst the attackers themselves, seeking protection by ground or extensions, were to move forward under their own fire, and through sheer force of will and numbers overwhelm their enemy with bullets. The protection aimed at was not to stop the flight of the enemy's bullets, but to stop the enemy's soldiers pulling the triggers of their rifles. It was not aimed against the mechanical end of the opposition, but against the human end, and as when on the defensive, even in the open, the human end only offered one quarter of the target presented by the attacker, and could fire more steadily and more rapidly, the attempt to protect an attack by destroying the defender became an all but impossible one. The fault in the

pre-war tactical logic was that though the mechanical theory of the military schools had gone so far as to embrace the human element, it had failed to mechanize protection, that is to produce a mechanical counter-agent to the bullet—the main enemy. Directly the war opened this counter-agent was rediscovered in the trench, which stopped the flight of the bullet, and in wire entanglements which stopped the forward movements of the human rifle mountings; but as neither earthworks nor entanglements could be carried forward by the attacker, these means of protection only resulted in strengthening the defense.

Thereupon the attacker virtually abandoned his traditional weapons of offense—the rifle and the bayonet—and set his reliance almost entirely upon artillery. By sheer weight of shell fire the enemy's trenches and wire were to be pulverized, thus protection was to be sought mainly through destroying the mechanical end of the enemy's resistance, which only incidentally included the destruction of the human end—the enemy holding the trenches. In April, 1915, the Germans reversed this process by using lethal gas, nevertheless both these attempts at protecting the attack failed: the first because it was extremely slow and costly, and the second because an antidote was soon discovered, the antigas respirator stopping the flight of the lethal molecules, and not, be it noted, attacking the man who launched the gas. Then came the tank which did exactly the same thing to the bullet—it stopped its flight.

The tank followed quite logically in this evolutionary military development. The bullet defeated the attacking pike, the trench defeated the attacking bullet, but the trench was useless to the attack unless it could be rendered mobile, and once the tank was introduced it was rendered so in the form of bullet-proof armour; further still the soldier was de-mechanized, for no longer was it necessary for him to be a gun-mounting. Moved by the machine, and being to all intents and purposes invulnerable to bullets, he could devote the whole of his thoughts and energy to the manipulation of his offensive weapons. In fact, by being divorced from the mechanical idea, he became master instead of slave of the machine.

THIS brings us to the situation as it faces us today, and the question is: what of the future? The war taught us the clumsiness, costliness and ineffectiveness of horde armies and mass tactics, because men are slow moving and extremely vulnerable to rifle and machine-gun fire. From its very opening it taught us the importance of armour—of protection in the form of earthworks as a counter-agent to the bullet. Towards its close it taught us that as static earth could be replaced by mobile steel the gun had become the superior weapon on the battle field. As both earth and steel can keep out bullets, that is cut short their flight, and as both can be destroyed by shells, its final tactical lesson was that we were in 1918 standing on the threshold of an armoured artillery age, and that there was no alternative to static armour and static guns except mobile armour and mobile guns; in fact, that the tank had come to stay for its period, and that if we refused to accept it, then we must prepare for static warfare in place of mobile warfare; in brief, for a war similar to the last.

It may be argued, as it frequently is, that the gun will beat armour and that not only is the present day tank vulnerable to shell fire but to heavy machine-gun fire as well. The answer to this argument is, that unarmoured man is still more vulnerable to the bullet, and that armour on land, like armour on sea, is not intended to keep out all projectiles

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The Guy-Vickers Armored Car After Recent Tests at Farnborough, England.

but a number of projectiles. For example: a capital ship is a weapon so powerfully armoured that she can only be met on equal terms by her like; the smaller shells only annoy her but the greater ones will sink her, yet were she to abandon her heavy armour she would at once be set upon by scores of smaller craft.

On land it is the same, tank can destroy tank and gun can destroy tank, but infantry cannot do so, yet were tanks to abandon their armour they would be a prey to every man equipped with a rifle. It is frequently suggested: why continue to arm them with rifles, why not arm them with antitank machine guns of .5 or .8-inch in diameter, for it is known that a .8-inch bullet will penetrate over an inch and a half of armor. Certainly this will be done; but logically where does it lead us? Such a weapon is obviously one which cannot be carried by a man, and is best carried by a machine, and when so mounted what will the man driving the machine ask for? He will ask for armor to protect himself against ordinary bullets, for without such protection he is easy prey to any man armed with a rifle or machine gun. An armored self-propelled antitank weapon is a tank destroyer, and its proper place is with the tank forces and not with the infantry forces, and this is certainly so if the infantry are not motorized; for though it is possible to protect a convoy of tramp steamers by means of an escort of destroyers, to attempt to protect a convoy of sailing ships by means of a similar escort is scarcely practical politics.

From this brief argument we can deduce three major factors of specification, or design, namely: Military organization will revolve around two essential weapons—the tank and the antitank, and all infantry will have to be motorized, not only in order that they may keep up with mechanized armoured forces, but because, if they are not motorized, they will continually be attacked by armed motor cars, that is, they will continually be faced by mechanized guerilla warfare and pestered to death. The foot soldier is in fact a thing of the past. When, in the South African war of 1899-1902, we were faced by a mounted enemy, we were compelled through force of circumstances to turn our foot soldiers into mounted infantry. So also today, were we to go to war in a civilized country, any man with any rifle in any car would be more than a match for any single soldier without a car. Men like Henry Ford, and not men like the late Marshal Foch, are the true parents of military design, organization and power.

IF for a moment we consider these three major factors they will at once suggest to us the beginnings of a new military instrument. Every fighting organization demands a protected base of operations, just as every warship demands a protected port to refit and to refuel in. Hitherto military bases have been mainly static fortresses, fortified areas and camps; but in mechanized warfare these bases must become far more mobile, for floating-docks rather than harbours are required. The infantry portion of the army is obviously that part which should establish the base of tank operations, for though it is unable to meet the tank in the field, it can improve and construct antitank obstacles and defenses. What does this mean? It means that motorized infantry must become antitank engineers, that they will discard their rifles, bayonets and entrenching tools, and will instead be equipped with guns, land mines and mechanical diggers; in other words—out-fighting weapons, in-fighting weapons and means of protecting these weapons and delaying hostile movement.

From the protected base air and armoured forces will operate, and what types of machine will armoured fighting demand? We start with the two essential types—the tank and the antitank, or better named the tank destroyer. The tank is the out-fighting arm and the destroyer the in-fighting, and both must seek protection not by constructing obstacles but by gaining information, thus we require a third type of machine.

In tank specifications in England we have, since the close of the war, consistently, followed a costly and erroneous path. We have been hallucinated by cost and size, and have hood-winked ourselves by inventing a misleading nomenclature—we talk of light, medium and heavy tanks, in place of laying down the functions of the machines we require and then building machines which express these functions. If in place we thought in terms of battle tanks, destroyer tanks and reconnaissance, or scout, tanks, our designing and building programs would be comparatively easy ones, because these names would suggest to us what we want.

HERE then are three ideas of three perfectly simple and straightforward machines—a battle tank, a destroyer tank and a scout tank, each of which supplements the other, and all three of which when combined form the nucleus of an armoured force. Round this nucleus many other machines may eventually gyrate, such as water-crossing tanks, bridging tanks, mine layers and mine destroyers, etc., etc. These types are all secondary, and I have not the space to consider them here; but before concluding this brief article I should like to accentuate an important point, namely, when thinking out the specifications of machines we are apt to concentrate almost entirely on the tactical or fighting side of the question. In every military organization it must be remembered that there are three essential "parts"—weapons, supply and control, or—means of fighting, administration and command. The supply and control of an armoured force are going to be quite different from the supply and control of a present day army, and unless this is realized, and unless the administration and command problems are being thought out simultaneously with those of tactical design, it will inevitably be found that when the three essential classes of machines are nearing perfection, however perfect they may be in themselves, to articulate them into a perfect whole, that is a combined force of all three, will be impossible.

Finally, what the designer wants is a complete war picture with foreground, background and perspective. He wants to see the base from which the force he is to design is to operate, also—how this force is to be supplied, and how in battle it is going to be controlled. He wants to know the function of each machine so that he may fit function to function. In short, fighting is but a function of war and not an end in itself: can a machine be easily supplied, efficiently controlled, quickly repaired; is it comfortable, is it manageable, easily maintained; is it intended for a hot country or a cold, for hard ground, sandy or muddy? These are all points which must be borne in mind if design is to be economical.

The Metal Trades in Peace and War

The Functions of the National Metal Trades Association

By L. M. Ross*

THE period from 1914 to 1918 clearly demonstrated the dependency of a nation upon its industries in the event of war. During that time the demand for certain materials mounted to unprecedented heights; the wheels of industry revolved at top speed; unemployment was at a minimum; prices, wages, and profits soared. But waste of capital on such a mammoth scale is economically unsound. Industrial leaders recognize that fact and, in common with the vast majority of the people, look with hope toward the negotiations between this Country and Great Britain and other foreign powers that aim at the curtailment of naval programs and the insurance of permanent peace. However, until the time actually comes when war is definitely a thing of the past those leaders of industry look to a sane program of preparation for the Country's defense.

Harold C. Smith, President, National Metal Trades Association.

Since the National Metal Trades Association represents about 1100 manufacturers in a vital industry, its activities naturally have a bearing on any plan of industrial preparedness. It is, as a matter of fact, almost impossible to exaggerate the importance of metal and the metal trades. It has been said that without them civilization is inconceivable. With equal truth, it could be stated that without metals modern warfare would be impossible. Bernard Baruch, at a critical period of the World War, declared, "the whole question of the western front is one of metals." Clarkson, in his "Industrial America in the World War," said, "the World War was moved and fought on steel."

One does not have to look far to see the vital importance of the factory and machine shop to the forces in the field. Armies are dependent directly on the metal trades for the actual armaments of warfare, for motors and locomotives, for airplanes and tanks, for derricks and cranes, and a multitude of other devices. But even that mighty service does not tell the whole story of the metal trades in modern warfare. The war cry of production and still more production must be met in this day not so much by human hands as by machines. Those machine tools are made in the shops and factories of the metal trades industry. Metal workers do not manufacture shoes for the Army but they turn out the machines that make those shoes. The same is true of uniforms and other equipment and even of many kinds of food. The machine age has thus made the metal worker the very keystone of national defense. It is obvious, then, that industrial preparedness must include the metal trades.

THE question naturally arises as to what form this preparedness is to assume. There is no peace-time market for many of the products most needed in war. It is neither practicable nor desirable to maintain industry at war-time pitch of production. What, then, is to be the program? Perhaps a parallel between man power and industry can answer the question.

It would be unthinkable to maintain a standing army of even approximate war-time strength. It is entirely possible, however, to develop the manhood of the country, not solely with the idea of war in mind, but for the more important tasks of peace. In so doing there is developed a healthy, capable citizenry adaptable to military service should the need arise. If some military training has been included in the education of those men, so much the better. The important thing is not so much that the country maintain a large army, but that it have readily available the makings of a large and competent force and the facilities for properly equipping such a force. Judged by that standard, the medical research worker who is fighting disease and the educator whose aim is a more intelligent people can be said to be preparing the defense of the country just as much as the officer who drills a company of soldiers.

The same principles hold true in industry. The aim of those interested in preparedness should be the development of healthy, progressive industry devoted to the pursuits of peace and convertible to war purposes should such an emergency arise. Just as an able-bodied man is superior to a sickly one as material for the army, so is a modern, well established and smoothly running business organization more readily adaptable to war-time activity than is one that is behind the times or involved in labor troubles or financial difficulties.

Comparable to special military training for the individual is the proposed system of educational orders for industry. The plan is to place peace-time orders for war materials with various factories so that those firms will have their own experience (and also some special equipment) to fall back upon should the need arise to produce those materials in large quantities. That, however, is a very specialized form of industrial preparedness. The broader, more general program aims at making industry more efficient and progressive in its ordinary pursuits. It is in this scheme that the activities of the National Metal Trades Association are of importance. Inasmuch as the Association will participate at the forthcoming Aberdeen meeting it may interest readers to know something about it.

*National Metal Trades Association, Chicago, Ill.

THE Associaton recognizes that its greatest task and responsibility is the creation and maintenance of the proper relations between employer and employee. It encourages a spirit of coöperation between the two groups that works to their mutual benefit. Under the direction of a national commissioner and secretary, the Association carries on a constructive program outlined by an administrative council, composed of leaders of the industry. This program is brought close to member firms through branches in 30 metal trades centers.

The insurance of an adequate supply of skilled labor is always a problem. The fact that it becomes greatly accentuated in time of war adds to its significance as a part of preparedness plans. It is a problem which the National Metal Trades Association frankly faces and is attempting to answer in its own industry through the work of the Department of Industrial Education.

Homer D. Sayre, Commissioner, National Metal Trades Association.

Under the direction of a capable committee and field men of broad experience, the department first concentrated its efforts on the problems of apprenticeship. A definite program of training was worked out and a fair degree of uniformity has been established on a subject formerly handled in a more or less haphazard manner. The department's publication, "Elementary Shop Practice," a text book in three volumes intended for use in conjunction with actual shop demonstrations, is well and favorably known throughout the metal trades industry.

The department also recognizes the importance of foremen in the modern industrial scheme. Because the foreman is, in a sense, the principal connecting link between owner and workman, it is important that he have a definite conception of his work and his responsibility. To fill the need of a satisfactory method of discovering, training and developing foremanship material, the department, after a two year study of the subject, outlined a course in foremanship. It consists of an "introduction," containing information for management; the "conference leader's manual," containing outlines and suggestions for foreman conferences; and fifty-two conference outlines which form the basis and material for foreman study groups. The Association's most recent publication is "Advanced Foremanship Course and Conference Leader's Manual," a continuation of the original foremanship course. Whenever possible the department's training activities are coördinated with those of industrial schools.

Another Association service of mutual benefit to members and workmen is that of the national and branch employment bureaus, the purpose of which is to bring employer and applicant together in the shortest time possible.

DURING the World War there was much talk on morale. To fighting forces it is, no doubt, a vital thing. It is none the less so in the ranks of industry. In shop and factory, devoid as they are of elements of glamor and glory, the maintenance of high morale is apt to present a more difficult problem than in the Army. It becomes a very subtle thing, resting on delicate foundations. The problem of developing satisfied working forces is not confined to periods of war. It is a constant thing, with many phases both social and economic. It is in this vast field that the Association's Department of Industrial Relations conducts its research.

The department endeavors to assist in maintaining a satisfactory adjustment of employees to their work life in the face of constantly changing economic and industrial conditions.

For each manufacturer to run the entire gamut of experiment in industrial relations would be both costly and unsatisfactory. What the Association's department affords is a clearing house for the information collectively gained in this line by a large number of firms. It is one of the best sources of information on these various subjects to which a member can turn. Its function is to investigate, study and report facts. No recommendations are made, conclusions to be drawn from the facts presented being left to the individual firm.

The fact that last year special service was rendered to more than two hundred members on almost a hundred distinct subjects indicates that the importance and value of the department's work is appreciated. In the same period the industrial relations field man visited 278 member shops and prepared 108 follow-up and 85 special reports among which the following subjects were covered: incentive plans of wage payment for direct and indirect labor, employment methods, operating cafeterias, operating suggestion systems, using the consulting specialist, and providing for more intimate contacts between employees and supervisors.

Special surveys have been made and the findings printed in pamphlet form on such subjects as "Experience with group insurance," "A study of employment pension plans," "Methods of wage payment," and "Employee medical service." Copies of these pamphlets were distributed to member plants and many were sold to nonmembers, some requests for copies even coming from abroad.

The significance and value of such material are being increasingly appreciated by men in business. It gives the individual firm a truer sense of its relation to industry as a whole and aids it in fitting itself advantageously into the general scheme.

If part of the aim of proponents of industrial preparedness is the maintenance of a healthy condition of peacetime industry it must be granted that the work of the National Metal Trades Association fits into their program. Its efforts in creating a more friendly and equitable relationship between workman and employer have resulted in a healthy condition of the metal trades, a condition conducive to prosperity in times of peace and to quick, effective coöperation with the Government in the event of war.

Military Aeronautics Today

Recent Advances in the Development of Army Aircraft

By James E. Fechet*

MORE than thirty years have passed since Congress first made an appropriation for the development of an airplane to be used for strictly military purposes. The $50,000 appropriated was spent under the direction of Prof. Samuel P. Langley, then Secretary of the Smithsonian Institution, on the construction of a man-carrying machine powered by an internal combustion engine. The Langley airdrome, as it was known, was the result of years of painstaking experiment and research on the part of Mr. Langley and his assistant Mr. Manley. Through the efforts of these men a tandem monoplane as well as a radial gasoline engine was constructed. Each was a marvel of lightness and strength for its day and each, undoubtedly, was far ahead of its time. Failure of this machine to meet the Army requirements, followed immediately by many editorials ridiculing the possibility of flight, indefinitely postponed Army activities in this direction until the Wright Brothers in 1903 demonstrated to the world that controllable flight by mechanical means was possible.

From the experiences of the French in 1871 during the siege of Paris, and our own experiences during the Civil War, the need for aërial observation was apparent. Balloons of a crude type were used during times of necessity and their value was sensed by military leaders. Scientists and research engineers of many countries endeavored to solve the problem but comparatively little was accomplished until the internal combustion engine, a power plant of remarkably light weight, had been developed. From the arrival of such power the possibility of flight and its use in a military way were never lost sight of. A decade then elapsed during which the use of aircraft gradually passed from the purely exhibition, or circus stage, to the military stage, which began a year or two before the World War of 1914-1918. The tremendous strides in the development of aircraft resulting from military necessity during the World War are well known, but the work following as regards military aircraft is perhaps less familiar to the citizens of the country. It is perhaps in order that we review briefly the situation as regards military aeronautics today.

Curtiss Pursuit Plane, P-5. Maximum Speed 185 Miles Per Hour; Service Ceiling 20,000 Feet; Equipped with Supercharger.

A GLANCE at our country's history reveals the fact that for two or three decades following each national emergency the efficiency of the regular standing army appears to have lowered. Surplus war material on hand at the end of these periods, many officers and soldiers having returned to civil life, and Congress and the people generally tired of considering war questions, have always had their effect upon the Army. Following the signing of the Armistice in 1918 a cessation of activities was, of course, inevitable but fortunately a portion of the experimental work on aeronautical equipment was continued by the Army at McCook Field, Dayton, Ohio. Several types of engines and aircraft under development at the end of hostilities were later finished, given thorough test, and records made of the results obtained. Much of this information is proving of great value, not only in a military way but to numerous commercial interests now striving to give aeronautics a prominent place in the country's transportation system.

Practically all military leaders of the present day concede the great effect of aeronautics upon all schemes of national defense. The employment of aircraft should not lessen the activities of various present branches of defense but should be the factor which will increase the efficiency of

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each branch, permitting it to accomplish its mission in a shorter period of time and with much less loss of life. A thorough study of the situation has taught us a most valuable lesson—that the development of proper aeronautical equipment must be carried on by highly specialized engineers during long periods of peace, in order that we may know the proper equipment and proper means of employing this equipment in times of national emergency. It is only by the careful coöperation of various branches of Government service, such as the Ordnance, Chemical Warfare, Infantry and Artillery, with the Air Corps that the greatest value of the new arm will be obtained.

Army Observation Plane, Douglas O-2H. Maximum Speed 137 Miles Per Hour; Service Ceiling 18,000 Feet.

So many uses for military aeronauties are present in any modern campaign that specialization of Air Corps equipment has become necessary. Military aeronauties may be divided roughly into several different classes. They comprise the pursuit or individual fighting units used for maintaining superiority of the air, observation units whose function it is to collect and deliver all possible information on enemy activities and friendly troops, attack units developed to harass the enemy at nearby points and to prevent the movement of his supplies toward the scene of action, and the bombardment unit whose duty it is to penetrate deeply into enemy country, if necessary, and attack points of strategic importance. In addition to these main groups the next emergency will, in all probability, call for the movement of troops in considerable numbers and of the rapid transportation of food and ammunition supplies to friendly troops.

In the Air Corps of the United States Army the activities are generally divided into three groups — training, operations, and matériel. The training of flying cadets at the present time is concentrated in California and Texas. It is standardized as far as possible in order that all rated pilots will have had the same general training and advance training in at least one specialized branch, such as pursuit or bombardment. The operations during peace times is largely a study of the most effective ways in which aircraft may be used in various schemes of national defense. Numerous maneuvers in conjunction, whenever possible, with other branches of the Army or Navy together with demonstrations of ability of the personnel and the efficiency of the equipment are of frequent occurrence, and are conducted under conditions simulating those of an emergency.

The Matériel Division is charged with providing the Army with up-to-date aeronautical equipment, which will ever be at least the equal of that possessed by any nation. This division is of extreme importance in that the development of satisfactory equipment must be conducted ofttimes over a period of years. The aeronautical engineer, so necessary to the development of this equipment, quickly learns that aeronautical engineering is indeed a compromise. One airplane cannot be found which will combine all the qualities desired in the different tasks which it is called upon to perform. Each kind of material used in the various parts of aircraft and their engines must be thoroughly inspected and ofttimes tested. The weight of all aeronautical equipment must be held at a minimum in order that high performance and ability to carry heavy loads may be attained. At the same time the strength of all parts must be the maximum obtainable for the weight in order to resist the strains and stresses of violent acrobatic maneuvers and hundreds of landings without failure. Engines must be selected for their particular work and thoroughly tested for reliability. During the manufacture of such equipment the cost of inspection alone may run as high as 10 to 12 per cent of the cost of the finished product, but it is indispensable to the production of equipment which will render the service necessary.

ONE of the most spectacular and most highly specialized units is that known as "pursuit." The main function of a pursuit airplane is to carry a machine gun and an expert pilot with all possible speed to such points as are necessary in clearing the air of enemy aircraft. Such a requirement necessitates a machine of extremely high speed, the ability to climb very rapidly and to perform well at high altitudes. It has been said that in an air duel or combat the advantage always rests with the man higher up. In England, rapidity of climb and speed at high altitudes are requirements placed even ahead of high speed at sea level. The pursuit planes used in the United States are

generally of the biplane type, having a wing spread of from 25 to 32 feet and an engine of from 400 to 600 h. p. The weight of such a machine empty is generally 1,900 to 2,000 pounds and loaded about 2,800 pounds. This machine powered with 410 h. p. air-cooled radial engine gives a speed of well over 150 m. p. h., a maximum altitude of 24,000 feet and a climb to 15,000 feet in 13 minutes. By the employment of geared propellers, superchargers, and higher speed and compression in the engines performances will be increased materially in future planes.

The best airplane, however, from an engineer's point of view may be worthless as a military weapon unless possessing the most up-to-date armament equipment. The Ordnance Department has been most coöperative and has done everything in its power to produce armament which is suitable for this specialized use on airplanes. The pursuit airplane is generally equipped with two machine guns which are fixed to the fuselage framework and aimed only by maneuvering the airplane. The guns which have been greatly improved during the last ten years are synchronized with the propeller in such a way that the bullets pass through the propeller disc but do not strike the blades. A favorite method of attacking an enemy plane is to conceal one's self as nearly in line with the sun as possible or behind a cloud and then to take a long steep dive which may increase the speed of the plane to 250 m. p. h. at the time of actual attack upon the enemy. This type of tactics necessitates an airplane which will acquire speed rapidly in a dive and withstand the strains of recovery. To stand on the edge of a flying field and watch a pursuit group take off in formation, execute several movements in formation, and fire at ground targets in formation, is indeed thrilling and gives one a little idea of the rapidity with which such a fighting unit may be moved.

One of the interesting developments in equipment for pursuit planes has been the substituting of ethylene glycol for water as a cooling medium in several planes having water-cooled types of engines. The air-cooled engine, it is generally conceded, gives the greatest amount of power per unit of installed weight but possesses certain characteristics which lead many engineers to believe that the water-cooled type of engine will yet be used on certain kinds of work. By the use of ethylene glycol, whose boiling point is 388° F., as a cooling medium it is possible to conduct the liquid from the engine to the radiator at a temperature of 300° F., which permits the use of a radiator of only 25 per cent the size of a conventional water radiator. This feature alone makes for added maneuverability in the airplane, about 5 per cent greater fuel economy, a reduction in weight of 90 pounds and an 8 to 10 per cent increase of speed of the airplane. The researches in this connection have been carried on by Air Corps engineers at Wright Field and in all probability will result in an increased performance in many types of Air Corps planes.

AERIAL observation was possibly the first tactical use to which the airplane was assigned. The ability to observe enemy movements, the location of enemy forces and supplies is of vital importance to the plan of any army commander. With the pursuit keeping the air free of enemy aircraft an observation unit can secure information for the regulation of artillery fire and direction of various ground movements. The standard observation plane at the present time is a single-engine two-place airplane, having a wing span of about 40 feet and a weight loaded of from 4,000 to 5,000 pounds. The observation plane is manned by a pilot and an observer and armed for defense in the event the friendly pursuit is not strong enough to maintain air supremacy. The observation plane will usually have an engine of approximately the same power as that of a pursuit plane but, due to the fact that its weight loaded is nearly 50 per cent greater, its climb will be much slower and its forward speed from 10 to 15 per cent less. The armament of the observation plane consists of one or two machine guns mounted similar to the mounting in a pursuit airplane and a machine gun in the rear cockpit operated by the observer to resist an attack from the rear and above. The speed of an observation airplane with full military load is usually 135 to 150 miles per hour, its maximum altitude about 18,000 feet and the time required to climb to 15,000 feet, approximately 35 minutes. Such an airplane may have a cruising radius of about 600 miles at a speed of 120 miles per hour.

The equipment of an airplane designed for this particular service is of unusual interest as the information desired must be obtained not only through personal observation but by use of complicated photographic apparatus. This information must then be delivered to a headquarters miles in the rear by means of radio communication, dropped messages, smoke and colored light signals, and delivery of photographs, services which in the future must be rendered at night as well as by day. To accomplish these missions, much ingenious equipment must be painstakingly developed, throughly tested and arrangements made for a possible production in quantity. Work is constantly being carried on with the object of improving the quality of the photographs and speeding up of their completion and delivery. At the present time a very interesting series of experiments is in progress in the Rocky Mountains the purpose of which is to increase the photographic range of our cameras. Capt. A. W. Stevens, photographer, and Lieut. John Corkhille, pilot, are endeavoring to make photographs of mountains 200 miles and more distant. The clearness of the atmosphere in this region should aid materially in this undertaking. Perfecting such methods and the equipment necessary will contribute greatly to the value of long range observation over active fronts. Cameras have been provided with haze filters which will facilitate the securing of good photographs of military value even during periods in which a hazy atmosphere exists. It is generally conceded that antiaircraft guns are factors to be reckoned with up to an altitude of nine or ten thousand feet but above this altitude the percentage of hits will be very low. Although important information such as the effect of artillery fire and enemy troop movements is relayed back whenever possible by radio, yet over active sectors it is quite possible that the air will often be so "jammed" by other radio activities as to render this method impracticable. This condition necessitates the returning of the plane to headquarters and actually dropping sketches and messages.

New cameras are now available which will photograph a strip of country 15 to 20 miles in width at a speed of 100 miles per hour, an accomplishment which is extremely valuable in the rapid map-making activities of a modern army. Single photographs may now be taken, developed and printed during flight, and dropped within a period of ten

Army Attack Plane, Curtiss Falcon A-3. Maximum Speed 147 Miles Per Hour; Service Ceiling 20,000 Feet.

minutes. It is possible that continued research will result in finding a means for sending this information back by television, enabling a commanding general at his post 20 miles back to watch certain phases of the action taking place.

A new field for the aerial observer has been opened up during the last few years by the use of a unique apparatus known as the supercharger. This device supplies air at sea-level pressure to the carburetor of the engine up to altitudes of about 30,000 feet, compensating for the steadily decreasing density of the atmosphere. A Liberty engine developing 400 horse power at sea level will develop only one-half that amount at an altitude of 20,000 feet if no supercharger is used. Good military photographs have been made from altitudes as high as 37,000 feet with high altitude cameras mounted in an airplane equipped with a supercharged engine. At these altitudes, the plane from which the photographs were taken, is invisible to ground observers. Thus far foreign nations have not appeared particularly interested in extremely high altitude observation but the Air Corps believes that it will find valuable application in future emergencies. Ingenious schemes must also be applied to the development of less spectacular but necessary items of equipment. Flying clothes and gloves must be electrically heated. Even goggles must be electrically heated to prevent the lenses becoming frosted and blinding the pilot. To raise the goggles momentarily may result in frozen eyelids while flying in the temperature of 40 to 80 degrees below zero usually encountered.

Still another phase of this work is the effect of altitude upon the crew. At altitudes above 20,000 feet it is necessary for the average person to supplement the oxygen contained in the atmosphere. A supply of liquid oxygen is carried in large unsealed flasks and the vaporized oxygen conducted to the face masks by flexible tubes. The slightest exertion at extremely high altitudes is ofttimes sufficient to cause unconsciousness. An interesting case of this was experienced by Lieut. J. B. Haddon, a test pilot of the Air Corps, who was sent out to give a new supercharged pursuit plane its altitude performance test. He climbed steadily until at an altitude well above 30,000 feet his oxygen tube slipped from his mask. The exertion expended in an effort to regain the tube rendered him unconscious. What happened during the fall from 31,000 feet to 7,000 feet where atmosphere of nearer sea-level density was encountered, no one will ever know. At 7,000 feet the pilot regained consciousness only to find his airplane in flames. Being utterly unable to extinguish a fire with so great a headway, he leaped to safety in his parachute landing some distance from the demolished airplane. This accident reveals some of the problems faced in the development of suitable equipment and is typical of experiences frequently encountered by those officers willing and even anxious to test new and untried apparatus.

It is probable that observation airplanes will for some time to come outnumber any other specialized type in the military service. The army which is able to keep its observation working uninterruptedly will possess an advantage difficult to overcome.

"GROUND Straffing" was the term applied by airmen during the World War to a peculiar type of attack against ground objectives. It is believed to have first been employed by French aviators against marching columns of soldiers and supply trains moving along the highways. It appears to have been looked upon first as a real "he-man" sport for aviators who were exceptionally "crazy." By the end of the war though, the results of numerous raids upon trenches, troops along the roads, railway trains, and even enemy airdromes had demonstrated beyond all doubt the strategic value of such hazardous missions and virtually established a new department in military aeronautics—one with which future military leaders must reckon. Several years after the signing of the Armistice the Air Corps became interested in developing special attack equipment and training a special attack group. Curtiss biplanes known as the "A-3," similar in construction to the Curtiss observation planes and powered with 400 to 550 h. p. engines comprise the equipment in service today. These planes are equipped with machine guns mounted in the wings and firing just outside the path of the propeller blades. Rear flexible machine guns are provided for the gunner who is located just back of the pilot as in the majority of regular observation airplanes. The performance

Curtiss Condor, Night Bomber B-2. Maximum Sp.e d 128 Miles Per Hour; Service Ceiling 15,000 Feet.

of this equipment is usually slightly superior to that of the observation airplane but its radius of action is generally less. An attack carried out by a group is indeed an awe-inspiring spectacle to the average individual. "The low-flying hellions" as they are often referred to and as they ofttimes style themselves in their insignia, will fly fifteen to thirty feet above the ground in open country "zooming" telephone wires, trees, and other obstructions until they are within striking distance of their objective. Then with all the fury their motto implies, they dive at dizzy speeds upon their prey raking the columns mercilessly with machine gun fire and small fragmentation bombs. Not only delayed movements and property destruction mark their path but shattered morale and cases of "nerves" are almost certain to be in their wake. The element of surprise is of great importance to the success of these missions and for this reason the flying approaches are made at a low altitude taking full advantage of the concealment offered by woods, valleys and hills. Strangely enough this type of service is popular with pilots and observers in spite of the hazards which invariably accompany constant flying at low altitudes.

Exposure to possible machine-gun fire during these attacks will undoubtedly result in providing the pilot's seat with light bullet-glancing armor as well as certain vulnerable parts of the engine. An interesting problem is intimately connected with this development. If each plane is provided with a quantity of armor plate, the pilots may be somewhat more immune to machine gun fire from the ground but at the same time must pay for this partial immunity with increased weight which means lessoned maneuverability. Certain pilots desire the added safety which arises from an extremely maneuverable airplane while others prefer the presence of armor plate which gives a greater sense of security.

Attack aviation will undoubtedly increase in importance with the years. It is not inconceivable that in a closely contested conflict each combatant will find the movement of supplies to be his most serious single problem and enemy ground attack airplanes his greatest single menace.

THE unusual interest of the people of this country in commercial aeronautics since the epochal flight of Colonel Lindbergh to Paris has apparently resulted in a strong demand on the part of the public for new airports, new passenger airlines and new airplanes of greater safety and capacity than heretofore thought possible. The commercial airliner of today is without question the direct outgrowth of the bombing airplanes developed during the latter part of the World War and the decade following. Bombardment aviation has therefore played an important part in producing suitable equipment for our domestic aerial transportation needs. Shortly after the signing of the Armistice the Allied nations found themselves with a surplus of large airplanes which were no longer required for war purposes. Each nation recognized at that time the great advantage of rapid communication and transportation systems with its own colonies as well as with other centers of population. England desired an airline to Egypt and India as an additional means of controlling her far-flung empire. France desired many commercial airplanes on hand which might, in a pinch, be used in a military manner. Italy, a little later, with a newly discovered ambition determined to make its equipment, in quality at least, the equal of that possessed by any nation.

Bombing airplanes then began to carry passengers in comfortably appointed cabins where not so long before bombs and machine guns had been located. From the very start, it was plainly evident that these lines could not be self-supporting even during the season when American tourists were frequenting Europe. Their integrity was maintained by large subsidies from their respective governments. New and more efficient designs have appeared from time to time until the commercial airplane is no longer an adapted bombing plane but represents a means of transportation whose safety and adherence to schedule is undoubtedly improving each year. Governments, in many cases, may now reverse the operation and learn valuable lessons from commercial activities.

The modern military bombing airplane is designed primarily for the efficient transportation of heavy loads over long distances. It is the bombing airplane which will strike at the very heart of a hostile nation perhaps a thousand miles from friendly soil. It is the bombing airplane which may meet and turn back an enemy fleet a thousand miles from a friendly shore. A satisfactory bomber from a military standpoint today must have a maximum speed of at

least 125 miles per hour and a long range cruising speed of well over 100 miles per hour. This plane must be able to climb with its full military load to an altitude of at least 16,000 feet in three-quarters of an hour. The medium type of bomber has a wingspan of from 80 to 100 feet, a total weight loaded of 14,000 to 16,000 pounds and engines totaling 1,000 to 1,500 h. p. Such a machine should possess a cruising radius, in calm air, of at least 650 miles while carrying a bomb load of at least 3,000 pounds.

The twin-engined bomber appears to be in greatest favor in this country at the present time, but it is not at all unlikely that a smaller single-engined monoplane type, in which many present desirable qualities will be sacrificed for high speed, will supplement the slower heavier duty machines.

Tactics followed by many countries at the present time during their periodical maneuvers indicate that bombing airplanes will operate in fairly close formation in order that they may offer the greatest protection to each other in the event of an attack by enemy aircraft. Two pilots, two machine gunners, a navigator and radio operator, and a bomber represent a typical crew as used on many of the foreign bombing airplanes today. The type of bombing planes in use can hardly be expected satisfactorily to carry out their missions unless a friendly pursuit has paved the way by keeping the enemy pursuit well occupied and in close contact. It frequently happens that friendly pursuit are unable to establish air supremacy in which case the bomber planes must fight it out. It is then that the defensive armament of at least three sets of machine guns must be used to ward off attack.

AN interesting development now being carried on is the equipping of planes with geared engines giving the propellers a speed of about one-half of that of the engine crankshaft. This propeller speed more nearly approaches the desired "ten revolutions for each mile of forward speed of the airplane" permitting the employment of higher speed engines while at the same time maintaining an excellent propeller efficiency. Up to the present time gearing has been considered somewhat more successful when applied to the water-cooled type of engine than to the air-cooled type.

Accurate records are being kept on the performances of water- and air-cooled types of engines as installed in bomber airplanes in order to choose the type more suitable for this particular work. The best airplane, though, is no better than its offensive equipment. It is necessary to provide sighting devices which will insure accuracy in hitting the objective. Sights must be so designed that adjustments compensating for altitude, forward speed, characteristics of the bomb to be dropped, and wind conditions may be made en route to the target, eliminating the "sighting shot." For any given set of conditions, there is only one spot in the sky from which a bomb may be released and score a direct hit upon a given point. The first part of the problem is to find that point, the second part to start the bomb on its way the instant you have found it. The release mechanism must operate as perfectly as the sight. Although the present apparatus leaves much to be desired yet progress is noted each year. A few months ago a bomber scored several direct hits from an altitude of 8,000 feet, upon a reinforced concrete bridge only twenty feet wide. In all probability, the accuracy of bombing will increase with time as will the efficiency of the bombs themselves. Bombs used today come in various sizes ranging from 25 pounders for pursuit attack to the 4,000 pound bomb which few airplanes are capable of carrying to a useful altitude. The excellent development and test work carried on jointly by the Ordnance Department and Air Corps at Aberdeen Proving Ground, Wright Field and other stations, is playing a most important part in our national defense.

The possibility of extremely long range bombing using machines equipped for night flying and refueling during flight was recently demonstrated by the simulated bombing of New York City. With Dayton, Ohio, as a base this bomber proceeded under unusually poor weather conditions to New York, bombed the Battery and flew to Washington, D. C., for its first landing after leaving its base. It is quite likely that bombing planes in future flights will sometimes take-off with heavy loads of bombs and nearly empty fuel tanks. Fuel will then be taken shortly after the take-off and the craft will proceed on its mission.

Several airplanes now being purchased by the Army are known as transport planes. The value of such airplanes lies in their ability to transport commanders, members of Congress and government officials rapidly. Limited quantities of much needed food or ammunition supplies, wounded personnel and even troops in small numbers also may be carried. The recent experiences of the Marine Corps in Nicaragua have demonstrated the value of aerial transports time and again. Their services will be indispensible wherever they can be protected from enemy pursuit.

During these days of naval limitations treaties and various disarming agreements for the promotion of peace, there is a most natural tendency to lose interest in equipment vital to the defense of our own soil. We should not strive to darken the skies with military aircraft during times of peace nor in any other way attempt to give an impression of military prowess. As citizens of this Nation, however, it is a duty to conduct such experiments and researches that we will at least be able, at any time, to place in the hands of our industries plans and instructions with the assurance that when the equipment is built, it will be satisfactory for the moment at least. This, then, is that kind of preparedness which, without fostering trouble, may prove indispensable to this country in some future hour of need.

LATEST improvements in military aircraft as described by General Fechét in the foregoing article will be included in the program of demonstrations at the Eleventh Annual Meeting of the Army Ordnance Association, Aberdeen Proving Ground, Md., Thursday, October 10, 1929. Hon. F. Trubee Davison, Assistant Secretary of War for Aviation, General Fechét and other officers of the Air Corps are arranging for a gala demonstration of Air Corps matériel and tactical flying maneuvers.

Antiaircraft Artillery

The Machine Age Opens a New Era in the Art of Gunnery

By G. M. Barnes*

ONE has only to examine the artillery matériel existing at the time of the Spanish-American War to realize the vast progress which has been made in the intervening period. Armies and navies, equipped with tools of 1898 vintage, would crumble almost without resistance before an equal force equipped with weapons of the World War. And still the march of progress goes on, so that the arms of the World War period will eventually become ineffective in comparison with later-day weapons. Thus one must expect that there will be radical changes in the tools of war.

Professional soldiers are prone to think that matériel and methods, which were successfully employed in one war, are more or less standard and can be relied upon to produce results in the next. The fact remains, however, that new weapons have such a tremendous effect upon tactics that each succeeding war has very little in common with the preceding one, and only a few of the more general principles can be applied. This process of development is now rapidly taking place in the branch of artillery with which this article deals, namely, antiaircraft artillery. A number of new developments have taken place recently, which are destined to have a far-reaching effect, possibly, on the whole science of artillery.

In attempting to combat aircraft the gun met, perhaps, the most formidable foe in its long history. Previous to the advent of the airplane, the power of the gun and its ammunition had been steadily increased to meet the gradual thickening and toughening of armor plate and to permit its reaching farther and farther to envelop its prey. The targets—fortifications, men and ships—were fixed or moved relatively slowly so that the finding of the range and the making of the necessary corrections for fire could be deliberate and the fire-control apparatus simple.

Then was developed the airplane, a foe of an entirely new character, which carried no armor, yet, due to its great swiftness, could defy the striking power of the gun. Here was a foe which, although wholly unprotected, could dart at its objective, carrying with it a real striking power of its own in the bombs held under its wings and in the machine guns pointing to the front and rear.

Fig. 1. Modern 3-inch Antiaircraft Gun with Loose Liner Removed. This Gun can be Relined in a Few Minutes.

Not that the guns on the ground were entirely helpless, as the World War official records testify, since one-fifth of all airplanes brought down were thus destroyed; but certainly the full efficiency of the gun could not be realized.

The development of the airplane was so rapid, and the demands for all types of guns were so acute during the last war, that the task of making the gun fully effective against aircraft would probably have been impossible of

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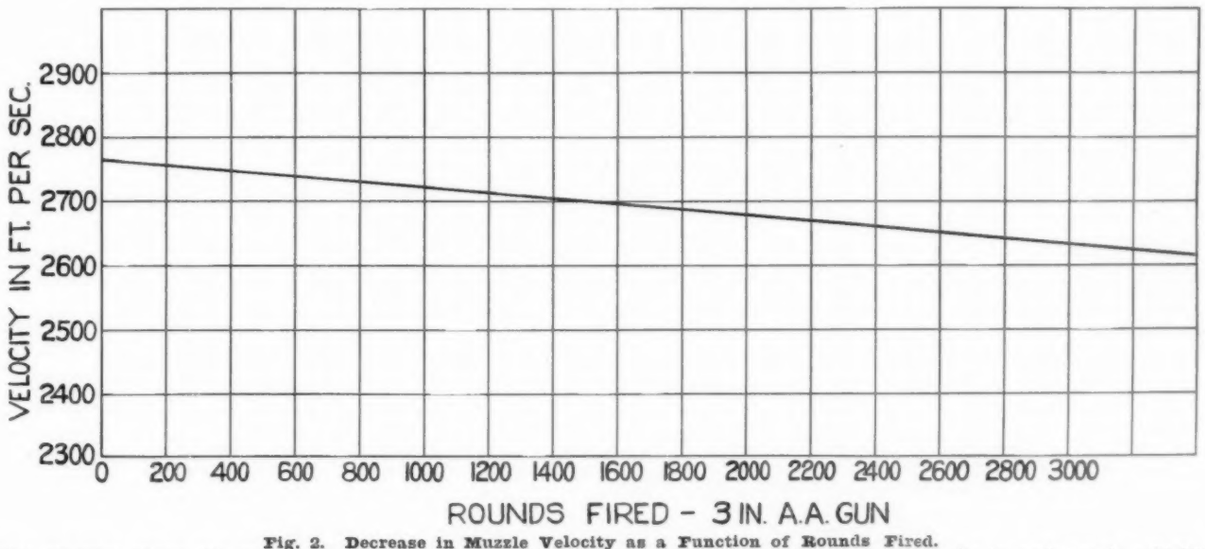


Fig. 2. Decrease in Muzzle Velocity as a Function of Rounds Fired.
This diagram shows the great advantage of the loose liner which can be replaced quickly before the loss of muzzle velocity or accuracy become detrimental.

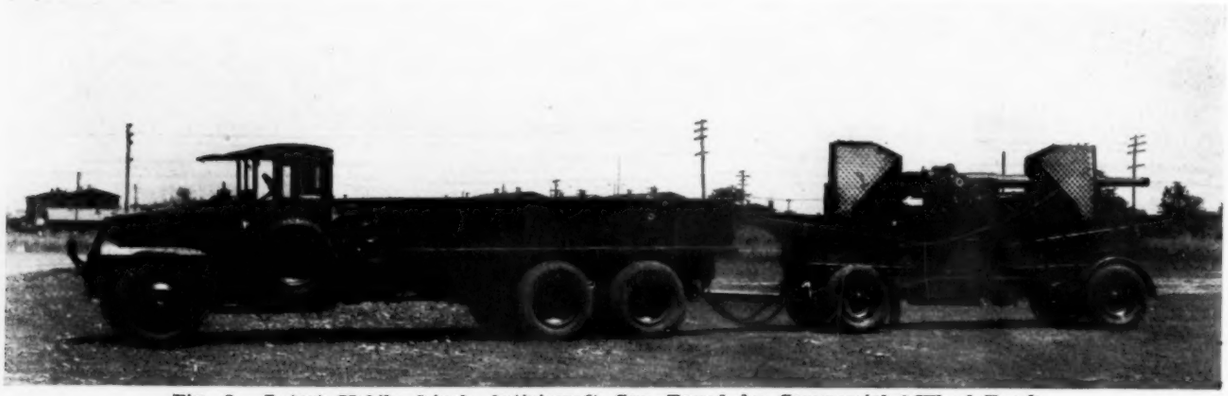


Fig. 3. Latest Mobile 3-inch Antiaircraft Gun Towed by Commercial 6-Wheel Truck.

accomplishment, even if a full appreciation of the required radical departures from existing types of artillery and methods of fire control had existed, which was certainly not the case.

After the war, ordnance designers all over the world turned their attention to the new problem of combating aircraft. These efforts were accelerated by the realization that, as the airplane became more and more effective, the question of defense against aircraft assumed greater importance.

War experience conclusively demonstrated that entirely new methods and matériel, differing radically from those which had previously been used for field or antiaircraft guns, must be devised if the full effectiveness of the gun were to be attained against these high-speed targets. It is hoped that this article will point out some of the more important developments which have made it possible for the gun to cope with the airplane.

MODERN ANTIAIRCRAFT GUNS. The muzzle velocities of guns have been increased gradually from year to year. Higher muzzle velocities give flatter trajectories, shorter times of flight and greater ranges. These desired characteristics can also be obtained by improving the ballistic form of the projectile. Therefore, these two methods of improving gun fire have gone hand in hand in the race for improved artillery.

Perhaps the most important post-war development in guns has been the introduction of the loose liner. (Fig.1). This is a thin sleeve carrying the rifling, which can be pushed inside the gun, and when in place forms part of the gun. It can be replaced in a very few minutes without dismounting the gun from its carriage. Previously, after the gun had been fired a certain number of rounds, its rifling became so worn that it would no longer give the projectile the requisite rotational velocity, and the fire became so erratic that the gun was considered worn out. It was then dismounted from its carriage and shipped back to a gun manufacturing plant for retubing, a manufacturing operation which required a considerable period of time. Therefore, unless the war were prolonged, the gun might not again reach the firing line. But more important than this consideration is the fact that with a high velocity the rifling is rapidly eroded, and as the firing progresses the gun gradually loses its accuracy. (Fig. 2). In modern antiaircraft fire where the goal is to place each round exactly at the target, this decreasing accuracy would be a serious matter but for the loose liner. Now, it is unnecessary to wait until the liner is worn out and inaccurate, because it is feasible to substitute quickly a new one making the gun equivalent to a new gun in a few minutes. The accuracy life of a 3-inch high-velocity antiaircraft gun is about 3,000 rounds. If great accuracy is desired, the liner might be replaced at the end of 1,000 rounds; thus, the accuracy of the fire would at all times be appreciably greater. It would be economical to reline even more often since the cost of a liner for a 3-inch gun is about the equivalent in cost of 100 rounds of ammunition.

Fig. 4. Modern Ammunition for 3-inch Antiaircraft Gun—Streamline Projectile and Mechanical Fuze.

THE GUN CARRIAGE. Carriages for mounting antiaircraft guns of the World War period were defective when considered from the standpoint of the latest fire control, in that they did not provide stable platforms for the guns, which moved at each shot. This seriously affected the accuracy of fire as at that time the sights were mounted on the gun carriages. Furthermore, the gun could not be accurately leveled, or, if leveled would not remain so during firing. Like all other artillery of the period, the mobile antiaircraft carriages could be hauled only at relatively slow speeds since the designs had not contemplated the use of high-speed trucks as tractors.

Thus, in attempting a complete solution of the antiaircraft problem, it was first necessary that an entirely new type of gun carriage be evolved, which not only would give complete stability at all angles of fire, but would also permit the gun to be accurately cross-leveled. A further necessity was that the gun carriage permit easy and rapid loading at all angles of traverse. These requirements have been successfully met in the new 3-inch antiaircraft carriage which has recently been adopted as a standard for the U. S. Army. (Fig. 3). To meet the demands of high speed, the carriage is mounted

on wheels equipped with roller bearings at the axles, and large balloon tires. Springs also have been introduced between the mount and the axles to prevent injury to the carriage mechanisms at high speeds. Upon arrival at the firing point, the gun can be put in firing position, or reverse, in 15 minutes. I do not think that it is generally known that the famous French 75-mm. field gun and practically all the field artillery of that period cannot be hauled at speeds of more than fifteen miles per hour without seriously damaging the mount.

AMMUNITION. The gun, the carriage and fire-control system for directing the gun at the target are simply means of getting the high explosive shell into position, where, upon action of the time fuze, its fragments will have a destructive effect upon the airplane. It is, therefore, necessary that the propellent powders give uniform muzzle velocities, the projectiles have the best ballistic shapes, and the fuzes function accurately at the times for which set. Since the war, great improvements have been made in propellent powders and in improving the ballistic shapes of antiaircraft shells. (Fig. 4).

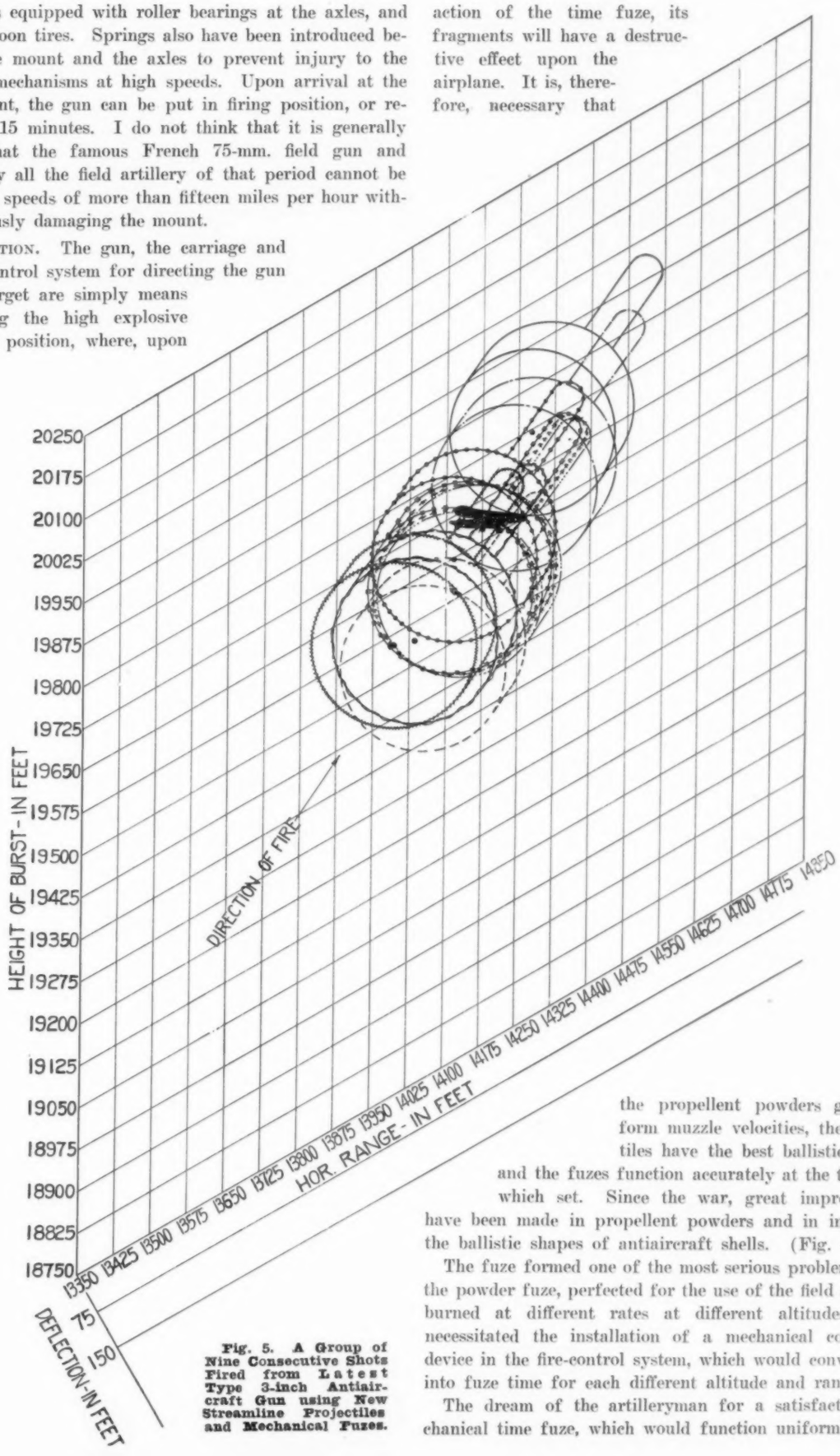


Fig. 5. A Group of Nine Consecutive Shots Fired from Latest Type 3-inch Antiaircraft Gun using New Streamline Projectiles and Mechanical Fuzes.

The fuze formed one of the most serious problems, since the powder fuze, perfected for the use of the field artillery, burned at different rates at different altitudes. This necessitated the installation of a mechanical computing device in the fire-control system, which would convert time into fuze time for each different altitude and range.

The dream of the artilleryman for a satisfactory mechanical time fuze, which would function uniformly at all

altitudes and ranges, has been realized within the last year. Thus one of the principal stumbling blocks to future progress, in still further increasing the effectiveness of gun fire against aircraft, has been removed.

ACCURACY OF FIRE. But what is the accuracy of one of these guns with its modern ammunition? I doubt whether many readers have any mental picture of what it amounts to at the target.

To illustrate what may be expected from the modern gun and ammunition, a group of nine consecutive shots, all fired at the same point in space, has been selected. The results are shown in the tabulated data below:

Number of rounds fired.....9
Fuze setting.....20 seconds
Muzzle velocity of the gun.....2,785 ft. per second
Mean horizontal range.....4,695 yds. (2.66 miles)
Altitude .....19,711 ft.

Results
Mean deviations (sum of all deviations divided by 9).
Horizontal range deviation.....14 yds.
Altitude deviation.....17 yds.
Deflection deviation.....1/2 mil = 2.3 yds.

To show this perhaps more clearly, the position of each burst in space has been plotted. (Fig. 5). Each burst also has been surrounded by a figure which represents the spread of the effective fragments of the 3-inch high explosive shell, from the point of burst. This figure was obtained from proving ground tests, and represents the distances from the point of burst at which the fragments from high explosive shell will penetrate a 1-inch pine board. A bomber is shown located 40 yards beyond the center of impact of these nine rounds. This is the point at which the guns are usually aimed, as theoretical considerations have shown this to be the optimum. A modern four-gun battery could fire these nine rounds in about five seconds. Firings at the range of approximately 2.6 miles and an altitude of 20,000 feet were selected to indicate the feasibility of engaging aircraft successfully at long ranges with modern artillery. (Fig. 6). At shorter ranges and lower altitudes, the bursts would be correspondingly closer together. This diagram, which was made from actual firing data, demonstrates that with perfect fire-control instruments, which would make it possible to direct the gun at the target with no errors, every one of these nine shots would have thrown high explosive shell fragments, which travel with a velocity of over 4,000 feet per second, upon the bomber. In other words, as far as modern guns and ammunition are concerned, if this group of shots be taken as typical, it should be possible to make practically every shot fired at an airplane effective.

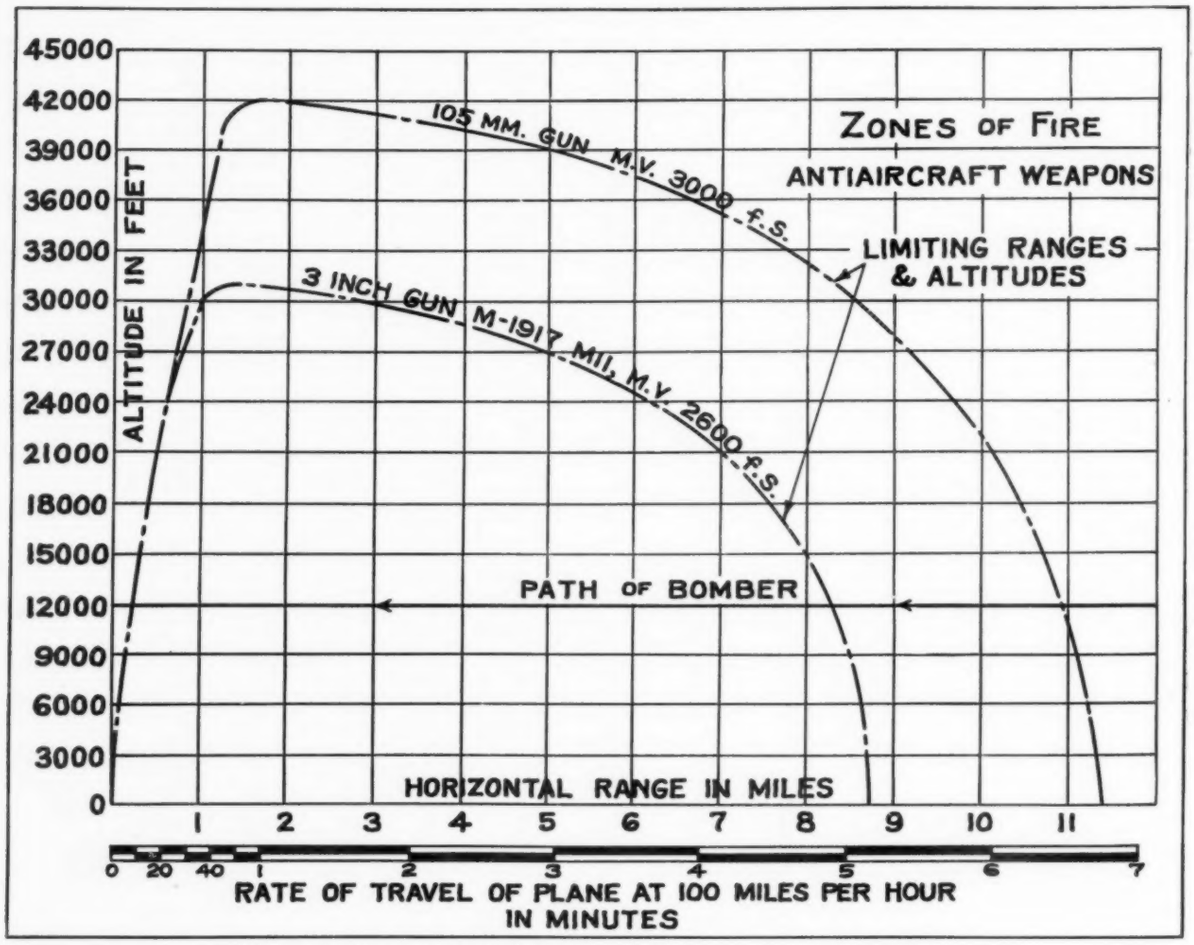


Fig. 6. Vertical and Horizontal Zones of Fire of Antiaircraft Weapons.

These data must bring us to the realization that the gun and its ammunition have already become so accurate that a destructive fire can be brought against aircraft at long ranges and high altitudes.

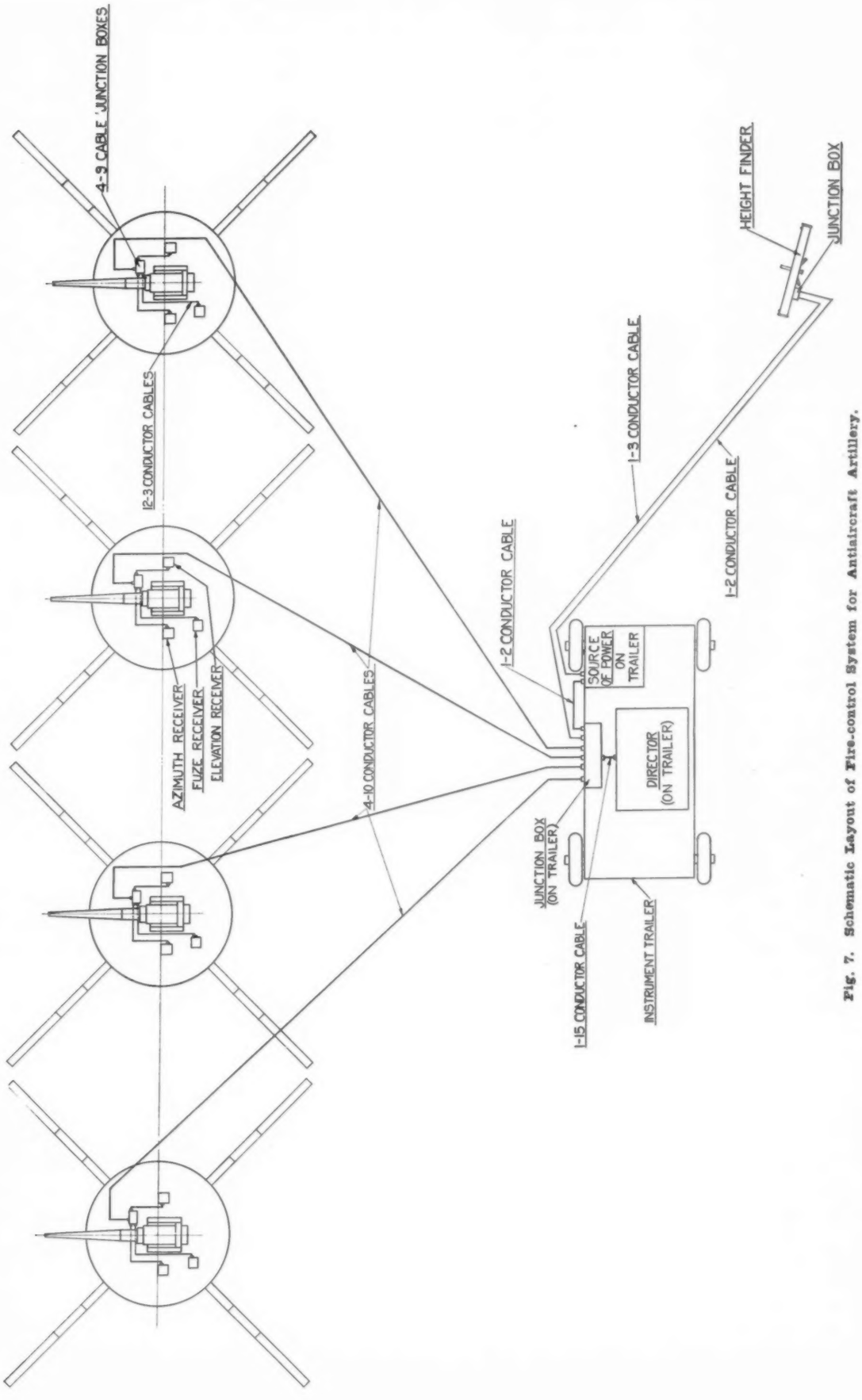


Fig. 7. Schematic Layout of Fire-control System for Antiaircraft Artillery.

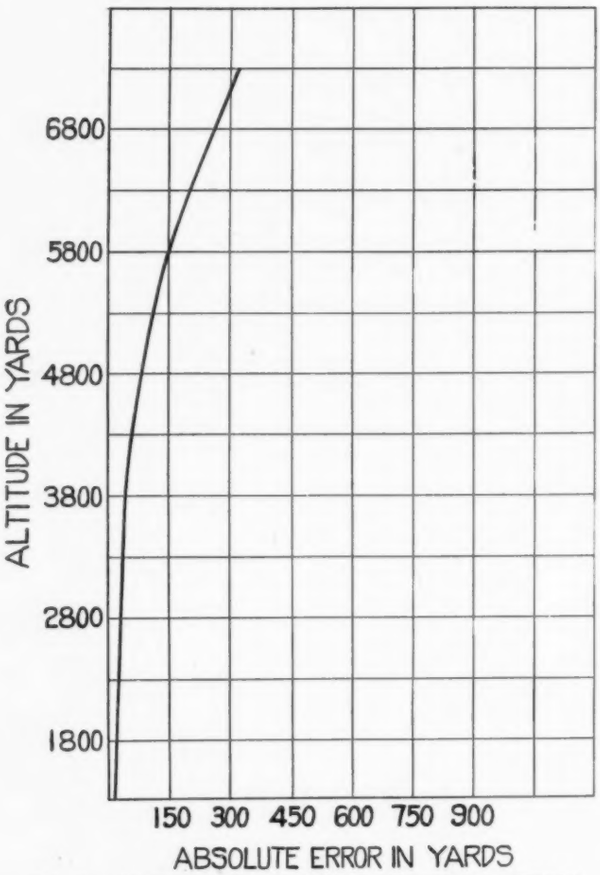


Fig. 8. Accuracy Test of 4-Meter Stereoscopic Height Finder under Field Conditions.

FIRE CONTROL. Let us now examine the battery fire control, or those instruments and devices which, when used together, direct the gun so that the shell and airplane will meet in space, to see what prospects there are of planting each shell at its proper point along the path of the airplane traveling 100 miles per hour or more.

The latest fire-control system for antiaircraft artillery is simplicity itself to the operators. (Fig. 7). There are three main parts to the system, (a) the height-finder; (b) the antiaircraft director; (c) the electrical data transmission system.

The height, which combined trigonometrically with angular height of the target, or the angle made by a line drawn from the gun to target with the horizontal, gives the range upon which the fuze-setting is based, and must be determined with the greatest accuracy. How successfully this has been accomplished with the four-meter stereoscopic height-finder is shown in Fig. 8. In this diagram the errors in altitude (in yards) are plotted as a function of the altitude of the target (in yards). This diagram was made by checking the altitude of the airplane, obtained by photographic methods, with readings obtained by the height-finder operator, under field conditions. The antiaircraft height-finder is a practical instrument which will give satisfactory results under field conditions, if given proper care. While on the average only one man out of every hundred can be trained to become an excellent stereoscopic observer, this does not form any bar to its use, since only one such observer is needed at a time for a four-gun battery. Thus, in time of peace or war, an adequate supply of efficient observers can always be obtained, if the proper steps are taken for selecting and training the men.

THE ANTIAIRCRAFT DIRECTOR. The modern antiaircraft director, which is the brain of the battery, is the instrument which simplifies and solves the four-dimensional problem of antiaircraft fire control. The four dimensions referred to are the X, Y and Z coördinates of the airplane in space, and the time setting of the fuze. Because of its intricate construction, it is as useless and unnecessary to attempt any detailed description of the working of the antiaircraft director as it would be to describe the mechanism of the present day printing press. (See Fig. 9). The machine must, however, compute accurately the successive positions of the airplane in space, mathematically determine its range, course and speed, and predict the successive future positions corresponding to a constantly changing time of flight. In addition, the following data must be algebraically added: (a) correction for wind (velocity of wind in miles per hour and direction of wind being determined and set into the instrument); (b) the drift of the projectile; (c) correction for muzzle velocity of the gun; (d) correction for atmospheric density; (e) corrections based upon observation of fire.

All the above corrections, except the last, are usually made within the instrument by using three dimensional cams.

The director is externally so simple that operators can be trained in an hour to operate it successfully and thus solve instantaneously the most intricate ballistic problems. While it would require a trained mathematician several hours to compute all the data for one position of the airplane, the director computes these problems instantaneously and continuously for the moving target. These computations having been automatically made, only three values need be sent to the four guns of the battery, namely, azimuth,

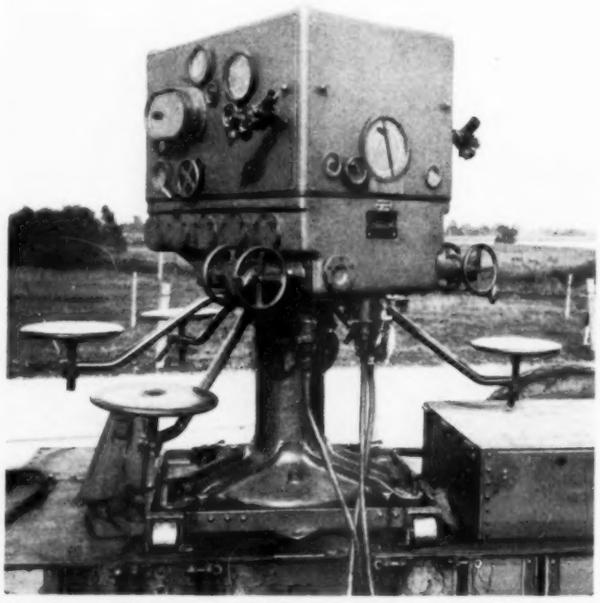


Fig. 9. Latest Type of Antiaircraft Director Showing Cables for Electrical Data Transmission System.

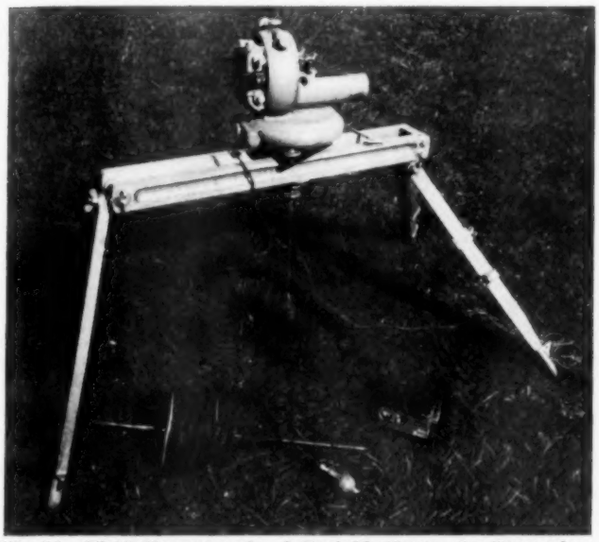


Fig. 10. Field Chronograph—A Portable Device for Measuring the Muzzle Velocity of a Gun in the Field.

quadrant elevation, and fuze-setting. But these values must appear at the guns instantaneously, and the guns be kept trained without any loss of time. At first thought this would seem impossible, but this is not the case. In the World War, (now the dark age of antiaircraft gunnery), these readings, having been determined by the incomplete instruments of the time, were telephoned to the guns, which were then set. Eight to ten seconds were allowed for this—a short time, but as far as antiaircraft fire is concerned—a century.

This loss of time and coördination between the guns and the firing data constituted one of the most serious bars to success in antiaircraft fire. Electrical transmission systems, discussed later, make it possible to eliminate entirely this loss of time and synchronization.

In the World War fire-control system, corrections were only approximately made as no automatic instruments for this purpose existed. These were lumped together and final adjustments were made by firing trial shots.

Now the basic idea is quite different, and it is the aim to evaluate properly each ballistic correction before the firing starts and to fire with fully corrected data so that the adjustments made as a result of firing trial shots will be small.

Fig. 11. Data Receiver for Antiaircraft Gun—Note Double Set of Dials.

The ballistic wind is measured by sending small rubber balloons to different altitudes, and observing the direction and velocity of the wind. Shrapnel or shell bursts with fuzes set for the desired altitude, may also be used for this purpose by observing the direction and speed of the smoke puff. These values are set into the machine, which then automatically corrects the firing data for these wind values, the laborious task of determining these corrections having been done by the ballistician and incorporated in the three dimensional cams within the director.

The drift of the projectile is accurately determined by proving ground firings at various ranges and altitudes, and these corrections are also incorporated in a cam within the instrument.

Previously, no attempt was made to measure the muzzle velocity of the gun from day to day as the firing proceeded and the gun eroded. The velocity was considered to be a fixed quantity, and errors, due to changes in muzzle velocity, were lumped with other corrections. The difficulty was that there were no instruments in existence which were practical for measuring muzzle velocity of the gun in the field. This velocity could be determined very

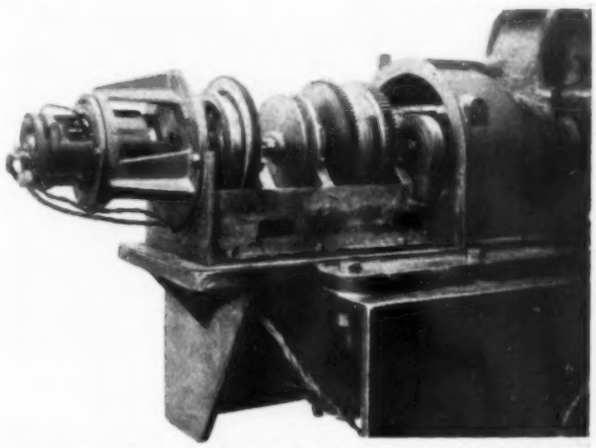


Fig. 12. Torque Amplifier—Electro-Mechanical Device for Keeping Guns Set in Azimuth and Elevation Automatically.

accurately by the instruments used in the Ordnance proving ground, but these instruments were too delicate for use in the field. Only recently, a very compact and rugged instrument (See Fig. 10) has been manufactured which will permit the muzzle velocity of a gun to be measured under field conditions with an accuracy of one-fourth of one per cent. Thus, one more previously unknown quantity has been removed from the fire-control problem. The velocity measured by this field chronograph is then set into the antiaircraft director, which will then automatically indicate firing data, based upon the selected velocity. The atmospheric density is also measured and set into the machine, and the ballistic corrections for atmospheric density are computed within the machine by means of an additional three-dimensional cam. Thus, the firing data, which are sent to the battery, have been adjusted for the conditions existing at the time of fire. And more important, all these computations are

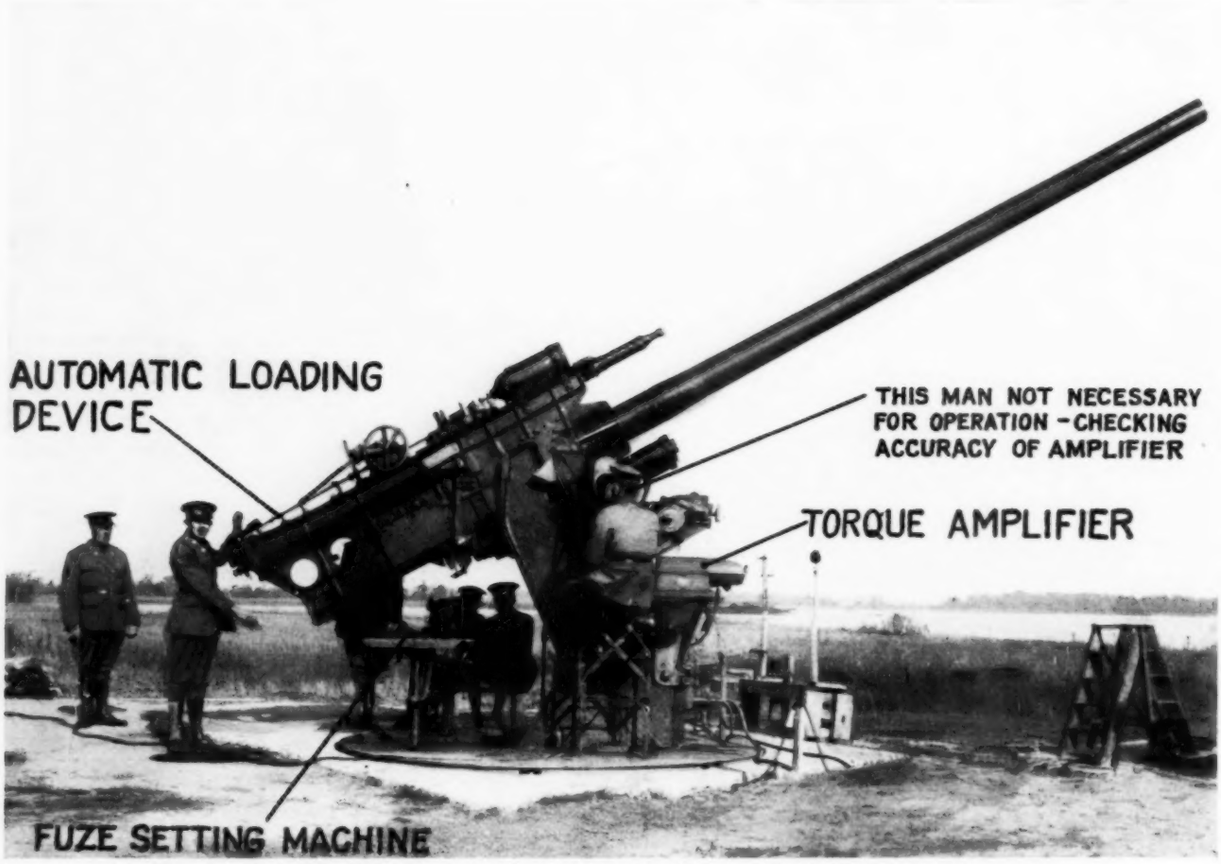

AUTOMATIC LOADING DEVICE
THIS MAN NOT NECESSARY FOR OPERATION - CHECKING ACCURACY OF AMPLIFIER
TORQUE AMPLIFIER
FUZE SETTING MACHINE

Fig. 13. High Velocity 105-mm. (4-inch) Antiaircraft Gun with Electrical Training Devices.

made instantaneously, and there is a continuous flow of corrected data to the guns.

The accuracy of the antiaircraft director has been carefully checked under field conditions by tracking an airplane in flight, using cameras or mirror position-finders simultaneously with the director. The records obtained from the cameras or mirror position-finders are used to compute trigonometrically the successive positions of the target in space, from which firing data can also be computed. These tests, which have been made for various ranges and altitudes, are too voluminous for publication in an article of this length. Suffice to say that these computations show that the accuracy of the director is well within the accuracy of the gun. These computations, however, have shown that in order to keep pace with the increased accuracy of the gun, more accurate height determinations must be made. Since the accuracy of the height-finder varies directly with the length of the height-finder base, it is only necessary to increase the length of the height-finder tube to arrive at the necessary accuracy to meet the situation. A careful analysis of the problem made recently has shown that a height-finder of about eight meters in length will be required to meet the accuracy of the gun and its ammunition.

RANGE TABLE FIRING DATA. No small part of the improvement in antiaircraft fire has been due to improvement in the firing tables which supply the basic data upon which all the cams in the director are cut. With the appreciation of the accuracy of fire, required to combat aircraft, came new proving ground methods for securing more exact firing data upon which range table computations are based. Photographic methods for determining the position of each burst in the sky, together with a photoelectric method for measuring times of flight of the projectile to points of burst, and similar refined methods have made possible firing tables of the greatest accuracy.

THE TRANSMISSION SYSTEM. If the guns could be located closely enough to the director so that mechanical shafting and gearing could be used to connect the quadrant elevation and azimuth output shafts of the director with the elevating and traversing mechanisms of the gun, then the latter would be kept continuously set to correspond to the future positions of the target without time lag. As the guns are usually placed 25 yards or more apart and the director 30 yards or more in the rear of the guns, it is impractical to use gearing and shafting. The same results are secured by using an electrical data transmission system which transmits these data instantaneously to the guns. There are two general types of these systems, namely, the step-by-step D. C. system and the self-synchronous A. C. system. After extensive tests, the latter system has been selected for antiaircraft artillery since it has the important characteristic that, when the current is applied, the dials at both the receiving and transmitting instruments synchronize themselves and read alike. In the D. C. step-by-step system the dials of the receiving and transmitting in-

struments must be synchronized by hand when the current is first applied or whenever the current is broken. The value of the self-synchronous instruments for antiaircraft use, where time is such an important factor, will be appreciated. The three transmitting instruments are attached to the three output shafts of the director, namely, quadrant elevation, azimuth and fuze-time shafts. The receiving instruments are mounted on the gun carriages. These receiving instruments have a double set of dials (Fig. 11); one set being controlled by the movement of the transmitting instrument and the second set being geared, for instance, to the elevating mechanism of the gun carriage. The operator turning the gun elevating mechanism has only to keep this set of pointers or dials in agreement with the set of dials being electrically controlled from the antiaircraft director. This insures that the gun is always set at the same elevation as computed by the director, with no time lag. The azimuth and fuze-setter receivers operate in the same manner. The data are transmitted electrically with practically no error, and a trained operator can follow the pointers, keeping the dials matched for a swiftly moving target, with errors of not more than one or two mils. When the electrical transmission system was first introduced, the using service was skeptical as to whether such a system would be sufficiently rugged to withstand field conditions. Actual tests have shown that transmission systems are more rugged and less liable to give trouble than field telephone sets, which were previously depended upon to transmit the firing data to the guns.

TORQUE AMPLIFIERS. For many years attempts have been made to lay guns in azimuth and elevation by electrical methods so that the guns could be trained from a distant point. Devices built for this purpose have been unreliable, costly and inaccurate. About three years ago the Sperry Gyroscope Company working with the Ordnance Department undertook the development of a new mechanism for this purpose. (Fig. 12). These efforts have been so successful that during the last two years the Ordnance Department has been able to direct guns automatically from a distant point without having any operating personnel at the guns except the loading detail. (Fig. 13). It has been found that the new electro-mechanical device will direct guns with greater accuracy than was formerly possible, using skilled gunners. The torque amplifiers are connected to the antiaircraft director through the same data transmission system, and the guns thus operated direct from the antiaircraft director. This device, which has been called a torque amplifier is rugged and relatively simple. It has been extensively tested at target practices in which targets towed by bombing planes were used. Occasionally one reads what are considered fantastic stories in newspapers of the possibilities of firing guns controlled only by mechanical robots. As a matter of fact this has already been successfully accomplished.

WE have seen that it is possible, using the latest guns and ammunition, to place a group of shots at a range of 2.6 miles and an altitude of 20,000 ft. so closely together that every shot may be expected to burst accurately at the selected point in space, and that if an airplane were caught in such a burst, practically every shot would throw high-velocity fragments upon the target.

We have seen that the newly developed fire-control system makes it possible accurately and continuously to locate an airplane in space, to predict its future position, automatically applying the necessary ballistic corrections, and to transmit these data instantaneously to the guns so that the latter can be laid accurately upon the target at all times. Further, that the guns can be trained electrically from the director without the use of gunners. We have seen that all these recent developments are making antiaircraft artillery more and more mechanical, depending less and less for accuracy of fire upon the operating personnel. The fair-minded individual must therefore admit the feasibility of bringing destructive fire upon aircraft.

Intensive tests extending over a five-year period, during which some 20,000 rounds of 3-inch ammunition have been fired at targets towed by bombers, have demonstrated the accuracy of antiaircraft fire. Antiaircraft artillery has thus pointed the way towards a tremendous opportunity for increased accuracy of fire for all types of artillery.

The present day field artillery matériel and fire-control have rested on their laurels for many years and have been little affected by the new machine age. Field artillery is still directed upon the target in the most approximate manner, and the necessary corrections in the firing data are mainly by observation adjustment. Gradually, during the latter part of the World War, high-speed targets began to appear within the range of the field gun, until now tanks capable of going twenty miles per hour across country, high-speed trucks, to say nothing of airplanes must be combated. The field gun is finding targets with which, due to its limited traverse and manual fire-control system, it can no longer cope.

As aviation is used more and more for commercial and military purposes, the role of the antiaircraft gun, now the most effective defense against aircraft, will become more and more important. It does not seem unlikely that eventually it will be necessary that all types and classes of artillery be designed, and have their fire-control system so arranged that they can combat aircraft. If this becomes the accepted rule, then all artillery will be primarily antiaircraft artillery in type, for, while antiaircraft artillery also can successfully engage targets on the ground, field artillery weapons of the present accepted standard cannot be successfully used against aircraft.

Perhaps the new antiaircraft artillery and its electro-mechanical fire-control system, which represent radical departures from present classical standards, will lead the way toward a new period in the history of artillery.

LATEST types of antiaircraft equipment as described by Major Barnes in the foregoing article will be exhibited and maneuvered at the Eleventh Annual Meeting of the Army Ordnance Association, Aberdeen Proving Ground, Md., Thursday, October 10, 1929. Day and night antiaircraft firings using latest types of guns and fire control will be conducted by selected personnel of the Coast Artillery through the courtesy of Maj. Gen. Andrew Hero, Chief of Coast Artillery.

The New Christie, Model 1940

An Estimate of the Tank and Armored Car Combined

By C. C. Benson*

"WALTER CHRISTIE, inventor, for exceptionally meritorious work in inventing, perfecting, and constructing at his own expense, a fighting machine for the armed forces of the United States. Mr. Christie, a private citizen, devoted five years of continuous effort and all of his personal means to perfecting a superior weapon. Despite financial hardships, he steadfastly refused to sell his invention abroad, and resolutely faced discouragements and delays incident to its acceptance by the United States. He has shown extraordinary patriotism and has rendered conspicuous service to the cause of national defense."

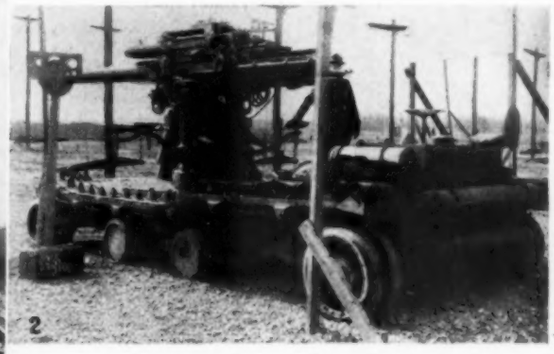
Although the above citation is fictitious and consequently is not recorded in the War Department archives, it may serve as an unofficial appreciation of what Mr. Christie has done. The five years of effort spent on his latest model is by no means the full measure of this inventor's work along similar lines. He had previously built a series of tanks and gun carriers for the War and Navy Departments, and before that had produced a number of successful commercial vehicles.

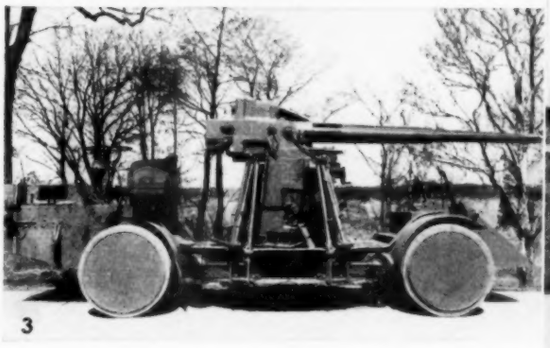
Twenty-five years ago he built a front-wheel-drive car which he raced with variable success against Barney Oldfield. His ideas were apparently too far ahead of the time, for the front-wheel-drive car, represented in the last New York Show by a dozen foreign models, is just now beginning to pay its way commercially. He also built fire engines which refused to wear out, and heavy duty trucks for many unusual purposes. One of his latest commercial products is a chassis suitable for mounting a yard crane. An automotive job that presents unusual difficulties appeals to Christie and keeps his fertile mind engaged until he can work out a solution.

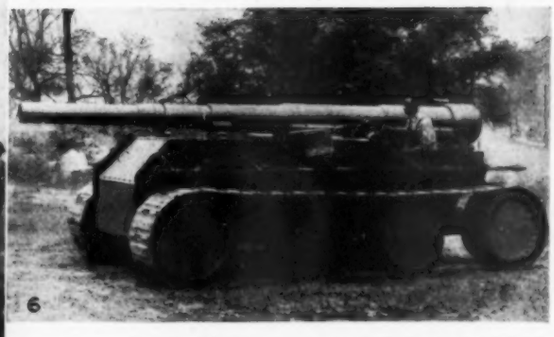
The Christie Combined Tank and Armored Car.

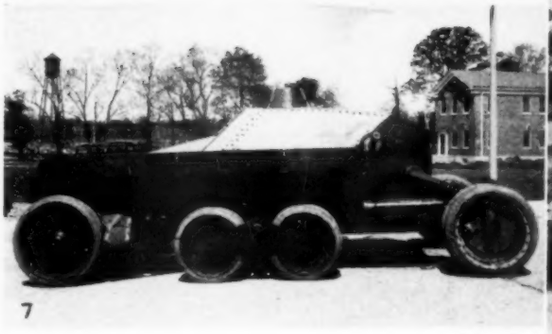
When the World War focused attention on our need for tanks and gun carriers, Christie interested himself in their construction. He had much to learn, for the problem was not merely to transport a given load, but also to provide for the effective use of the "pay load" in combat. From the start he was impressed with the need for a machine that could travel on either wheels or tracks, and he stuck doggedly to that idea through all of the development work that he carried out under the supervision of the Ordnance Department. Some of the machines that he built for the Ordnance Department are shown on page 113. They represent the expenditure of approximately a million dollars—a sum which indicates that the Ordnance Department backed Christie's ideas rather heavily. Each of the machines

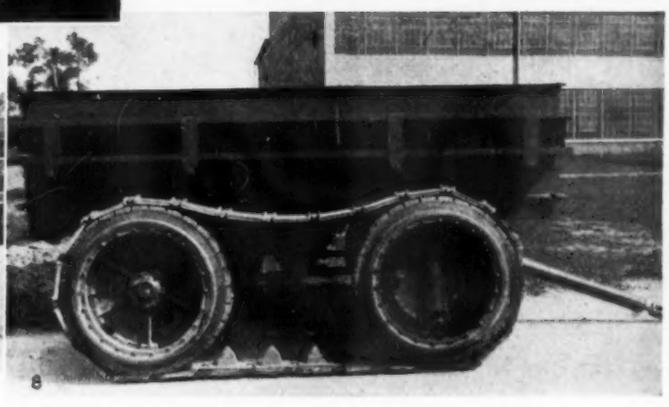
*Historical Section, General Staff. Major, Cavalry, U. S. Army.











Christie Vehicles Purchased and Tested by the War Department.

1. Christie self-propelled mount for 8-inch howitzer. 2. 4.7-inch antiaircraft gun motor carriage (Christie). 3. 3-inch antiaircraft gun, Model 1917, mounted on Christie truck. 4. Christie mount for 75-mm. gun and 105-mm. howitzer. 5. Christie tank (first construction). 6. Christie self-propelled mount for 155-mm. gun, G. P. F. 7. Christie wheel-track tank. 8. Christie combination wheel and track 3-ton trailer.

built during this series of experiments had many good points, but always there was some feature that baffled the designer. These machines cannot be classed as failures, and yet no one of them was an outstanding success. They are interesting now as showing steps in the evolution of the superior fighting machine which Christie has now produced.

Christie went on his own in 1923 with a check for $100,000 from the Ordnance Department in his pocket. He was then nearly sixty years old and might well have sat down to rest a while. However, he did not choose to sit. The tank problem had beaten him in the first campaign, but he refused to accept defeat. He went to work in his own shop with a few skillful helpers and the backing of his own private means. His hundred thousand melted away,* and nearly double that sum besides, during the five years that he worked on the new model. Financial folly, perhaps, but Christie was more interested in solving his problem than he was in making money. His confidence in himself was justified, for he has solved the problem and now offers us the new Christie, Model 1940.

MODEL 1940 is a suitable designation for this machine because it is easily ten years ahead of its time. In building it, Christie applied all the knowledge he had gained in previous work to a new set of basic specifications which he drew up for himself. He saw the need for reserve power in the engine, greater elasticity in the running gear, more speed, and more responsive controls; and set himself the task of building these features into his new machine. He retained the best feature of his old machines—their ability to use wheels on the road and caterpillar tracks across country. Tactically and mechanically his ideas show keen appreciation of what the fighting man needs. In the new design he placed the fighting compartment in front where the driver can see and the gunner can shoot; the power plant he put in rear where it can work efficiently without obstructing the driver's vision or the gunner's aim. His power plant—at present a 338-horsepower Liberty engine—supplies ample reserve power for hard pulls. Instead of having to creep up a slope in low gear, as all our other machines do, the new Christie draws on its reserve and charges uphill in high. This feature is vitally important because modern antitank defense relies heavily on the inability of present machines to ascend slopes rapidly enough to avoid destructive fire from antitank weapons. These weapons have been greatly improved since the World War, but the best of them will have difficulty in hitting a machine that travels across country at forty miles an hour.

To attain such speed it was necessary for Christie to develop and perfect a new type of running gear. Light weight, strength, long life, and extreme flexibility are its outstanding features. By a clever arrangement of powerful springs and strong levers, this new running gear reduces the unsprung weight of the machine to a minimum and enables it to traverse uneven ground rapidly without excessive vibration. At 25 miles an hour the machine goes over a 12-inch log with scarcely a ripple. The elimination of vibration and shocks saves the driving mechanism from rapid deterioration and permits members of the crew to devote more attention to combat missions. The strength and endurance of the track have been proved repeatedly in tests and demonstrations. Last November this machine made a trip on hard surfaced roads from Fort George G. Meade, Md., to Gettysburg, Pa., and return—144 miles—between breakfast and lunch. On wheels, going to Gettysburg, with only such delays as were incident to traffic, the running time was a little over two hours. On self-laying tracks, returning from Gettysburg, the running time was two hours and thirty-five minutes—an *average* of nearly 28 miles an hour. To make this average, which is respectable going even for a pleasure car, the machine had to move along at the rate of 45 miles an hour or better whenever traffic permitted. Running gear that can stand such punishment shows championship quality.

The power and speed of this machine would be of comparatively little use without responsive controls. Here again Christie has scored a distinct success. The driver can operate his steering levers with the pressure of a single finger; he can turn the machine about in half its length going either backwards or forwards, and can cut figure eights at a speed that would shame an international polo pony. The physical effort required to guide this machine, either on wheels or tracks, is so slight that the driver can give most of his attention to what is happening out in front. When he has to change pace or direction he can do so easily, in a flash. Under skillful hands like those of Christie's helper, Leo Anderson, this machine has the agility of a wildcat.

THE new Christie is now undergoing thorough tests to determine definitely its powers and limitations. As the main features of these tests have already been published

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***Editor's Note: The following table shows the vehicles purchased by the War Department from Mr. Christie as well as the amount paid to him in the purchase of his patent rights covering the construction employed in this type of vehicle:**

Date	Quantity	Materiel	Amount
12-22-16	1	Pilot 3-inch A. A. carriage	$ 7,880.00
12-13-17	4	Production 3-inch A. A. wheel carriage	60,000.00
12-29-19	1	1st 155 G. P. F. combined wheel and track-laying carriage	67,500.00
10-30-18	1	Experimental carriage for 8-inch howitzer (Salvage parts used for above 155 G. P. F. carriage)	86,960.00
3-26-20	2	Carriages for 75-105-mm. guns	95,000.00
3-13-20	3	Carriages for 155-mm. guns	150,000.00
6- 1-20	1	Design and manufacture of 4.7-inch A. A. carriage	83,000.00
10- 3-20	1	Repairs and alterations to one 155-mm. carriage (pilot carriage rebuilt)	6,000.00
6-27-21	4	Furnish and install 4 speedometers on four 155-mm. carriages	300.00
6-25-20	1	Design and manufacture of 3-inch A.A. carriage	78,000.00
8-18-21	1	Overhaul and repair one 155-mm. carriage. (This is one of production 3 sent up from Camp Jackson and now at Aberdeen)	5,400.00
9-23-21	1	Repair and modify 75-105-mm. carriage. (This one was sent to Hoboken from Aberdeen and thence to Fort Sill, Okla.)	2,200.00
11-22-19	1	Tank (first construction)	67,000.00
6-15-21	1	Tank (rebuilt)	15,000.00
10- 8-20	1	Trailer (approx. cost)	15,000.00
		Total, account manufacture	$ 739,240.00
		Total, account patents	100,000.00
		Grand total	$ 839,240.00

The item of $100,000 in the above table, account patents, was an initial payment made to Mr. Christie for the purchase of manufacturing rights under his patents and further improvements thereon.

Of the total, account manufacture as above, the first two contracts listed in the amount of $67,880.00 were not for the combined wheel and track type of vehicle.

Of the vehicles listed above the following were tested by the using service:

1. **4—3-inch A. A. wheel carriages.**
2. **4—155-mm. G. P. F. combined wheel and track-laying carriages.**
3. **2—75-mm. gun—105-mm. howitzer combined wheel and track-laying carriages.**
4. **1—Tank (remodeled and rebuilt).**

In every case the vehicles were reported as unsatisfactory. The remaining vehicles did not progress beyond the proving ground stage of testing.

In view of the Government's long-time encouragement of Mr. Christie and of the very considerable sum of money it has invested in his developments, we sincerely hope that the statements of Major Benson concerning the latest of Mr. Christie's vehicles will prove to be justified. We hope—but we realize that experience only can determine.

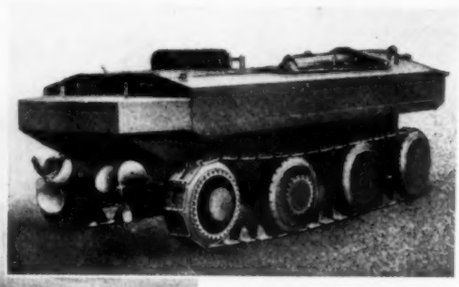
The Latest Christie Vehicle to Operate With Tracks or on Wheels.

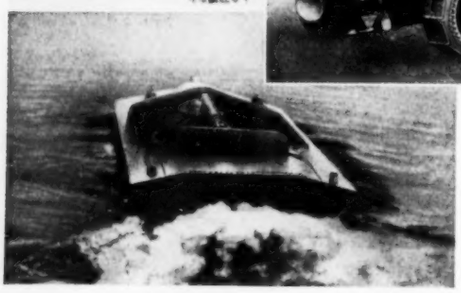
on the screen, in Sunday pictorial sections, and in the daily papers, there seems to be no reason for withholding this information. The hastily assembled machine that was used in the initial demonstrations at Fort Myer and Fort George G. Meade during October and November of last year, has since been practically rebuilt. Its present appearance is shown in the accompanying photographs. We may disregard the details of the fighting compartment because they can be changed to meet the particular needs of those who adopt the machine. As it stands, the machine weighs 17,200 pounds. The addition of a turret and heavier guns, if desired, would increase this weight considerably, but the machine has plenty of reserve power and is strong enough to carry anything up to 12 tons without serious alteration. It can be arranged to accommodate several machine guns, a 4-inch mortar, or a 75-mm. gun; and a crew of three men. Its average cruising speed across country is about 20 miles an hour. In speed tests conducted recently under the supervision of American Automobile Association officials, the Christie made 42.55 miles an hour on tracks, and 69.23 miles an hour on wheels. The distances were accurately measured and the time was recorded automatically by electrical timing devices. The test runs on tracks were made on a level field of sandy loam; the road tests on a straightaway stretch of concrete highway. We cannot expect to utilize these high rates of speed except in emergency, and then only momentarily; that the machine can attain such speeds without mishap indicates sound principles of construction and stamina.

In a demonstration given at Fort Meade on July 19th, the Christie showed surprising ability to negotiate a swamp. With cleats (growsers) bolted to the track plates, it waded into muck and water that appeared to be quite impassable and moved about at will. Unfortunately, the muck was only four feet deep at the worst part of the swamp; consequently, the machine could not fully demonstrate its powers. It crossed the swamp several times with apparent ease, pushing a mass of mud and vegetation ahead of its bow and leaving a clean-cut canal in its wake. With a machine of this kind, landing on an enemy's shore will be less of a gamble than heretofore. Instead of using landing beaches that are protected by underwater barbed wire and machine guns, the attacker may plow his way ashore at some unprotected point and take the enemy in flank or rear. It would be interesting to see what effect a hundred Christie machines, as a part of the attacking force in maneuvers, would have on our plans for defending the Panama Canal. Without similar machines at their disposal, the defenders would be seriously handicapped; with them, the plan of defense would be strengthened.

OTHER tests justify the conclusion that this machine can serve the Army in many ways. It can cross a 7-foot trench, climb a 45° slope, surmount a 3-foot vertical wall, crush barbed wire entaglements, and crash through underbrush. It would go roughshod over mesquite and cactus. In bad weather it can operate more effectively than any other combat agency. It can be made impervious to gas attacks. It endows the members of its crew with a sense of power: instead of being isolated individuals subject to the manifold terrors of the battlefield, they become a team in which each man raises the morale of his companions. They have confidence in the ability of their machine to surmount great obstacles, and in their own ability to carry the fight to the enemy. In estimating the combat value of this machine, we should consider fully its effect upon morale—

The Christie Amphibian





the human element is still supreme. If we consider the Christie simply as a power plant, with highly efficient running gear and certain space that can be utilized for the "pay load," its possible uses are more easily understood. It becomes a powerful tractor, a cross-country cargo carrier, or a front line fighting machine, according to details of superstructure determined by the branches concerned. A single type of standard chassis can be made to serve all branches.

First let us consider some of the combat uses. These will naturally depend upon the chief characteristics of the weapon—mobility, partial protection for the crew, fire power and shock action. The most obvious purpose of this weapon is to destroy the enemy's tanks; for until our troops have reasonable security against tank attacks they cannot operate freely. We oppose the enemy's aircraft primarily with aircraft of our own; his cavalry with cavalry; and similarly, his tanks with tanks. With its speed, power and all-around fighting ability, the Christie would fill admirably the role of tank-destroyer. When used in this capacity, it would lend valuable assistance to all branches. Cavalry, with its tactical doctrine built on mobility, fire power, and shock, is naturally akin to the Christie. Cavalry needs armored cars for security and reconnaissance work; and tanks that are fast enough to accompany the maneuvering mass or even extend its operations in combat. For exploitation, pursuit and raids, the Christie would be invaluable to cavalry. It could help materially to protect cavalry, on the march or in bivouac, from the enemy's tanks and aircraft. Infantry needs similar protection on the march and in camp; in combat, it needs tanks to precede the foot troops, to work in the closest coöperation with them, and to exploit their successes. A fast machine like the Christie can cover much ground laterally, and can do work for the Infantry far more thoroughly than can a slow one. Under modern conditions, the fast machine will be operating long after the slow one has been destroyed by antitank fire. The smaller Coast Artillery antiaircraft weapons, and searchlights, if mounted on the Christie chassis, would acquire strategical and tactical mobility that would double their usefulness. The heaviest artillery pieces could be moved about and supplied with ammunition far more readily than is possible with present means. The new Chemical Warfare mortar, a remarkable weapon of great power, would find many new uses if given the cross-country mobility that the Christie can provide. This machine could be used with terrible effect to carry tons of casualty-producing chemical agents into the enemy's lines. One hundred men with 50 Christie machines could put over a gas attack that would dwarf the most powerful concentrations used during the World War, and there would be no laborious preparations to warn the enemy of his danger. Driving by compass, they could operate at night, in fog or smoke, in sleet or rain; and whether our chemically equipped air forces were available or not, the enemy would get no rest. The Field Artillery could mount a 75-mm. gun on this chassis, and thus solve the vexing problem of providing a self-propelled gun for special purposes. By standardizing the bulk of the automotive combat vehicles in any mechanized force that may be created, the Christie chassis would greatly simplify all matters connected with procurement, supply, replacement, repair, maintenance, control, and operations of the force as a whole. Standardization of the fighting machine chassis is a vitally important factor in the efficiency of a mechanized force. This fact bears directly upon the selection of automotive equipment for units of all branches that will participate in the formation of our future mechanized divisions.

Suitable superstructure would convert the Christie into a useful cargo carrier. Men, machine guns, ammunition, rations, gasoline, oil, grease, and supplies of all kinds, could be transported rapidly on the road and across country. Supply dumps could be farther to the rear without jeopardizing efficient service, the road net restrictions would be less binding, reloading would be minimized, and carrying parties would be less in demand.

TACTICAL application should accompany technical progress in the development of new weapons. We now have an opportunity to secure a fast cross-country fighting machine which I believe is the best in the world—the Model 1940 Christie. To fit a weapon of this type into the combat team, for either close coöperation or independent action, will require drastic changes in our present combat tactics. What changes will be necessary cannot be fully determined until war tests our theories. In the meantime, the subject deserves serious study. The Infantry School has begun to study problems that involve the employment of a mechanized brigade, and, despite serious handicaps, has made considerable progress in its efforts to stimulate thought on this subject. The Infantry is vitally concerned not only in the offensive uses of the new weapon but also with defense against it. The introduction of this fighting machine will affect all combat branches and supply agencies. No one branch or service can solve all phases of the problems it presents. Christie has given us in his new machine more technical progress than Great Britain has secured during the past ten years from the expenditure of some sixty-five million dollars. However, in tactical methods and practical experience with fast fighting machines, the British Army is far ahead of us. Technical excellence will avail us little until tactical thought in our service as a whole catches up with the procession.

Centrifugal Casting

Adaptability to High Explosive Steel Shells

By Roy E. Paine*

CENTRIFUGAL casting of metals has attracted the attention of engineers and inventors in the metal industries for over a century, with the result that centrifugal casting processes have been developed for the manufacture of cast-iron pipe, piston rings, bronze gear blanks, thin-walled metal tubing, and steel billets for rolling. Centrifugal casting processes can be considered as important competitors of customary casting and forging processes. High-explosive steel shells have forms which are readily adaptable to centrifugal casting and this paper points out the possibilities of substituting centrifugal casting for common casting and forging practice. Centrifugal casting can probably meet the physical, metallurgical, and economic requirements of high-explosive shells.

Since man began to cast metals, many objects have been made which are symmetrical about at least one axis, and it is not unlikely that many unrecorded attempts have been made to utilize centrifugal force in the casting art. The first recorded successful attempt to cast in a rotary mold is contained in the English patent of Anthony G. Eckhardt in 1809. The process received considerable attention and attained minor commercial importance during the following one hundred years, but during the last twenty years technical development and research have placed the art in a position of industrial importance. At the present time cast-iron pipe is made successfully by several centrifugal processes, and the product has been in use long enough to demonstrate its superiority over sand-cast pipe. The most recent developments of the process are destined to bring about radical changes and economies in the production of steel for rolling purposes.

The history of developments in the centrifugal casting process is too long for detailed consideration in this paper. The purpose is to bring out salient features in development and application, so that the possibilities of adaptation to the production of shells may be suggested. Consequently, the historical discussion which follows is brief and necessarily far from exhaustive.

IN 1809, Anthony G. Eckhardt, of Soho, Middlesex County, England, described all the fundamental forms by which centrifugal castings might be made. These fundamental forms readily divide into the five major divisions of the centrifugal casting art: 1. The methods in which the mold rotates in a vertical position about a vertical axis; 2. The methods in which the mold rotates in a horizontal position about a horizontal axis; 3. The methods in which the mold rotates in a horizontal position about a vertical axis, or vice versa; 4. The methods in which the mold has both a horizontal and vertical rotation about a central axis; 5. The methods in which either a vertical or horizontal mold is rotated about an inclined axis.

Although Eckhardt covered the fundamentals of the subject well, he described no constructions by which the molds were to be rotated, and did not, so far as is known, put his invention into actual operation.

Thirty-nine years passed before Thomas G. Lovegrove, an American, furnished the next step in centrifugal casting development. In 1848, he took out patents covering an apparatus for rotating a two-part pipe mold about a horizontal axis. Lovegrove's patents contain the first information as to how rotation of a mold was actually accomplished. The development of the centrifugal casting of pipes took place in England at about the same time that it took place in America. Andrew Shanks patented a pipe-casting method which insured uniform thickness of wall and eliminated cores. In 1852, he was casting iron pipe 3 inches by 12 feet and also iron cylinders which were afterwards cut apart and flattened out to form sheets.

In 1859, Sir Henry Bessemer, the inventor of Bessemer steel, cast bars, plates and rods of malleable iron or steel from which he removed the gases by centrifugal force. Rails rolled from steel manufactured by Bessemer's method were free from blow holes. Full details of Bessemer's experiments were never published.

Between the years 1860 and 1885, Joseph Whitley of Leeds, England, working either independently or with other engineers, perfected many ideas which have had considerable influence on developments in the art. His patents covered such subjects as the casting of iron wheel tires in molds coated with clay; the methods of distribution of the metal in the mold; the lining of the molds with heat-resisting materials to conserve the heat in casting; the control of the casting thickness by weighing the metal before pouring; and, the removal of the casting from the mold by means of a screw.

The process has been of practical value for about fifty years, for in 1882, locomotive drive wheels were cast, sound and clean, at the low speed of 40 to 50 r.p.m.

Little was done with the process during the first fifteen years of the 20th century, but during the past fifteen years, centrifugal casting in several fields has been of commercial importance. The greatest development along a single phase of the casting industry has taken place in the production of cast-iron pipe during the last ten years. In 1914, Demitri Sensaud de Lavaud invented the de Lavaud process which is now used extensively in this country and abroad for the manufacture of many sizes of cast-iron pipe. Modifications of this process, such as type of mold, type of pouring spout, etc., are the main differences in other commercial pipe processes, as the Hurst-Ball process and the Stokes process. The developments of pipe-casting processes have been possible through the perfection of minor details in machines proposed by early inventors in the field.

The latest development in centrifugal casting has been the use of hot molds at temperatures up to 2,000° F. for casting of steel rolling mill billets and thin metal tubing.

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*Metallurgist, Stanford University, Calif. This article was awarded first prize in the 1929 annual essay contest sponsored by the California Post, Army Ordnance Association, open to members of the R. O. T. C. Ordnance Units at University of California and Stanford University.

The developments of the hot mold have been made by Leon Cammen of New York City. In his bottleneck mold, 30 tons of steel are cast in the form of billets for rolling. Billets cast by this method are free from shrinkage cavities; consequently, there is no discard and 100 per cent of the metal cast goes into the rolled product.

The expenditure of money and energy on the part of inventors and foundrymen during the long period of centrifugal casting development has had several main objectives. In 1898, Lewicki,[1] the first authority to write extensively on the subject of centrifugal casting, defined these objectives as follows:

"1. To produce dense castings, free from blow holes, and as a result having greater strength.

"2. The elimination of the use of a core resulting in economy of operation.

"3. To fill the molds completely and insure sharp outlines in the castings.

"4. To influence the chemical changes in the metal during casting.

"5. To make possible the combination of two or more metals in a casting."

THE reader is naturally interested in the principle involved in the centrifugal casting of metals, and in the reasons for realizing the objectives as noted by Lewicki. When a mass of molten metal in a mold is rotated about an axis, the metal is forced against the walls of the mold and due to the ultimate strength of the mold material, the walls of the mold exert an equal and opposite force on the molten metal. The force exerted by the molten metal is the centrifugal force, and the force of resistance exerted by the mold walls is called centripetal force. The centrifugal force is equal to the product of the mass, the radius of the mold, and the square of the angular velocity of rotation, and is directed away from the axis of rotation.

In the centrifugal casting process rotation of the mold is about either a vertical, inclined, or horizontal axis. Casting about a vertical axis is of commercial importance in the manufacture of gears, railroad car-wheels, piston rings and similar objects. The horizontal mold is extensively used for the casting of iron pipe. Shells can be cast about either a vertical or an inclined axis, and the following mathematical discussion deals with rotation about either of these axes.

Lewicki claims that Huth was the first to advance the theory that the free surface of a molten metal rotated about a vertical axis has the shape a paraboloid of revolution. Merriman[2] in his "Treatise on Hydraulics," first published in 1889, demonstrates that water "behaves in exactly the same manner," and he believes that the fact has been known for about a century. "It does not appear that Huth's work in this line goes back beyond 1892." The formation of the paraboloid cavity occurs with rotation about vertical or inclined axes only, and the length of the cavity increases rapidly as the axis approaches the horizontal, in which position the paraboloid is replaced by a cylinder.

That the cavity formed in a rotating liquid has the form of a paraboloid of revolution has been proved by several writers on the subject of centrifugal casting, and may be found in text books on hydraulics.

Fig. 1 and the following mathematical derivation of the equation of the centrifugal parabola are adapted from Wood.[3] The Y-axis, at any angle B with the horizontal, is the axis of the mold, the axis of rotation, and the axis of the inside of the casting. The curve $y = f(x)$, represents in plane section the interior free surface of the liquid metal during rotation, and the inside cavity of the casting after solidification of the metal, and (x, y) is any point on the interior free surface. At w, (x, y) the weight

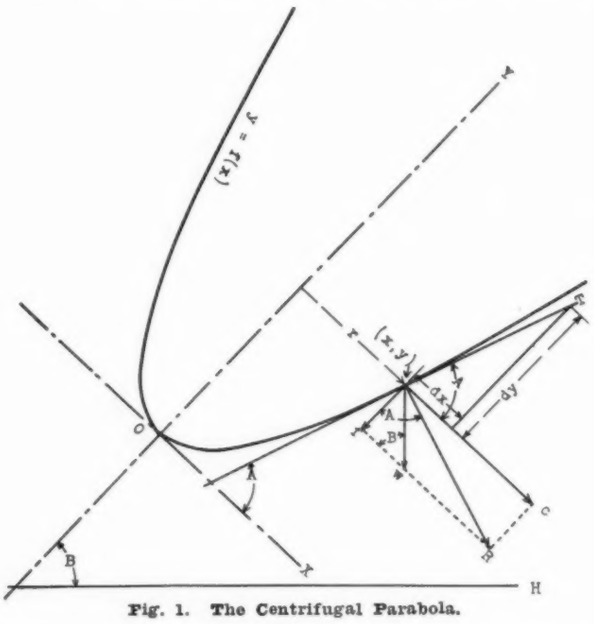

Fig. 1. The Centrifugal Parabola.

of a particle, acts vertically downward. The component of w, f, parallel to the Y-axis is equal to wSinB. When B equals 90°, f and w coincide. The component of w parallel to the X-axis has no effect upon the free surface of the casting, "because as the mold rotates, this force pulls the particle alternately towards a horizontal diameter and away from it, and is thus neutralized."[4]

The following notation is used in the derivation of the equation of the curve:

m = mass of particle at (x, y).

w = weight of particle at (x, y), $= m/g$.

g = constant of gravity $= 32.16$.

r = radius in feet at (x, y).

v = circumferential velocity in feet per second.

c = centrifugal force, acting parallel to the X-axis $= mv^2/r$.

n = speed of rotation about Y-axis, in revolutions per second.

[1] Lewicki, Ernst, *Ueber Zentrifugalguss* (June 25, 1898). *Zeitschrift des Vereines deutscher Ingenieure*, vol. 42, pp. 719-724.

[2] Merriman, Mansfield, Treatise on Hydraulics, (1903) p. 72; (1906) p. 72; (1916) p. 63.

[3] Wood, R. F., Centrifugal Casting Calculations, (May 1925), *The Metal Industry*, New York, vol. 23, pp. 186-189.
Similar derivations can be found in the following papers: Lilienberg, N., Centrifugal Casting, (July 1922), *The Blast Furnace and Steel Plant*, vol. 10, pp. 375-379.
Cammen, Leon, Centrifugal Casting, (1922), *Trans. A. S. M. E.*, vol. 44, pp. 261-297.
Merriman, Mansfield, op. cit.

[4] Wood, R. F., idem.

$v = 2\pi rn$.

A = slope of the tangent, T, to the curve at (x, y).

B = angle of inclination of the Y-axis with the horizontal, H.

f = the component of w parallel to the Y-axis.

R = the resultant of the forces acting upon the particle at (x, y).
This force is normal to the tangent, T.

dx = the differential of x.

dy = the differential of y.

Equation of the curve; $y = \frac{2\pi^2 n^2}{g \sin B} x^2$

From Figure 1

$$\tan A = \frac{dy}{dx}$$

$$\tan A = \frac{e}{f} = \frac{e}{w \sin B}$$

$$\text{then } \frac{dy}{dx} = \frac{e}{w \sin B}$$

$r = x$

$$\text{then } e = \frac{mv^2}{x} = \frac{w}{g} \cdot \frac{(2\pi nx)^2}{x}$$

$$e = \frac{4\pi^2 n^2 w}{g \sin B} \cdot x$$

$$\text{then } \frac{dy}{dx} = \frac{4\pi^2 n^2 w}{g} \cdot x \frac{1}{w \sin B}$$

$$\text{and } \frac{dy}{dx} = \frac{4\pi^2 n^2}{g \sin B} \cdot x \text{ (note-5)}$$

Integration of the differential equation gives:

$$\int dy = \frac{4\pi^2 n^2}{g \sin B} \int x dx$$

$$y = \frac{2\pi^2 n^2}{g \sin B} \cdot x^2$$

The curve passes through the origin so there is no constant of integration. This is the equation of a parabola, and the free surface formed when a liquid rotates about a vertical or a horizontal axis is a paraboloid of revolution.

From relationships noted above and from Fig. 1 it is possible to derive several useful equations for the control of centrifugal casting speeds and dimensions. These equations are given by Wood.

THE centrifugal casting process has attained considerable commercial importance in the manufacture of cast-iron pipe, piston rings and similar objects. It has been used to advantage in the casting of non-ferrous metals, and with the developments in the Cammen process it is likely to influence the future production of steel for rolling mill purposes. The properties of centrifugally cast metals are superior to the properties of sand-cast metals, and the following results obtained in manufacture illustrate the point.

In 1918, Burgess[6] at the Bureau of Standards examined six steel cylinders produced centrifugally by the H. W. Millspaugh process. The range of analysis of the steel was as follows:

Carbon	0.18 %–0.48 %
Manganese	0.44 %–0.56 %
Sulphur	0.024 %–0.055 %
Phosphorous	0.013 %–0.055 %
Nickel	2.33 %–2.90 %
Copper	0.052 %–0.090 %
Chromium	0.04 %
Silicon	0.19 %–0.65 %

Burgess remarks, "The results, comparing the several grades of steel in the condition as cast and after heat treatment, are of considerable interest as indicating what may be expected from this method in the production, for certain shapes, of sound steel, that is, free from physical defects and chemical segregation, and thus with practically no waste material to discard. As will be shown, it is also a field particularly adapted to the elimination of forging and boring operations and the substitution for the former of heat treatment to produce the desired characteristics in the resulting product."

And further amplifying the effect of heat treatment Burgess summarizes, "The effect of *heat treatment* in improving the physical properties of such castings is very marked. The results suggest that the properties of such castings suitably treated may rival those of forgings of the same chemical composition."

Experience with casting iron piston ring cylinders about a vertical axis has shown that the resulting product is 25 per cent stronger than the sand-cast product, and the same writer has produced iron castings, about an inclined axis, having 65 per cent greater strength than the sand-cast product.[7]

The greatest use of the centrifugal casting process has been made in the production of cast-iron pipe. In the United States at the present time there are over a dozen plants producing pipe in this manner, and the method is used also in England and on the Continent. Pipe cast by the de Lavaud process has physical properties markedly superior to those possessed by sand-cast pipe.

STRENGTH OF PIPE[8]

	6 inch sand cast	6 inch de Lavaud
Wall thickness	0.50 in.	0.39 in.
Per cent decrease		22
Bursting pressure	2,475 lbs./in.²	3,730 lbs./in.²
Per cent increase		50.7
Tensile strength	14,600 lbs./in.²	29,200 lbs./in.²
Per cent increase		100

At the Bureau of Standards[9] corrosion tests have shown that the finer grain of the de Lavaud pipe renders it very resistant. At the University of Toronto, Gillespie[10] stated that "the strength in tension and cross-banding, the resistance to shock, and the stiffness are about twice as great for machine-made iron as for the sand-cast product."

[5]The disappearance of w explains the fact that the calculations for speed and for internal shape in centrifugal casting are unaffected by the specific gravity of the material cast.

[6]Burgess, G. K., Tests of Centrifugally Cast Steel, (June 7, 1921), U. S. Bureau of Standards Technologic Paper No. 192.

[7]Rathbone, J. A., Centrifugal Casting of Iron Piston Rings. (Sept. 1924). *Western Machinery World*, vol. 15, pp. 299-300.

[8]Capron, J. D., The Centrifugal Casting Process, (1927), *The Blast Furnace and Steel Plant*, vol. 15, pp. 376-381.

[9]Logan, K. H., Soil Corrosion Investigation, (1927), *Am. Fdymens. Assn.* (pre-print) No. 27-10, 39 pp.

[10]Gillespie, Peter, A Departure in Pipe Foundry Practice. (Sept. 1922). *Journal of American Water Works Association.*

Hurst,[11] who has been connected with the production of centrifugal castings in England for a number of years, gives considerable information which illustrates the superiority of centrifugally-cast pipe over sand-esat pipe.

Tests on nonferrous alloys have shown that in this field, too, the centrifugal casting is superior to the sand casting. A cylinder, eight inches in diameter with a one inch wall thickness, cast about a horizontal axis, had the following properties.

ANALYSIS OF METAL[12]

	Near bore	Near outside
Copper	80.40%	79.08%
Tin	11.56%	12.25%
Lead	8.04%	8.85%

These analyses show the effect of the centrifugal force on the heavy metals and the Brinell hardness reflects the displacement:

Brinell hardness near bore	101
Brinell hardness near outside	90

Tensile properties of specimens from this casting compare favorably with the tensile properties of sand castings of the same analysis.

TENSILE PROPERTIES

	Sand Cast	Centrifugally Cast	Per Cent Increase
Tensile strength	24,000 lbs./in.²	39,200 lbs./in.²	63.4
		40,000 lbs./in.²	67.6
Elongation	9%	14%	55.5
		15%	67.7

INVESTIGATION has shown that the increased properties of centrifugally-cast metals are due to the fine grain structure of the metal as compared with the structure of metals sand-cast. Cammen[13] compares an alloy steel of about 1.1 per cent carbon and 1.5 per cent chromium, cast centrifugally with the same steel cast in a stationary mold. The metal cast in the stationary ingot-mold has a clearly defined dendritic structure with large coarse grains, and requires heat treatment and mechanical work to refine the grains. By the centrifugal process the steel is obtained with fine grain structure, purely pearlitic with no excess of cementite. The characteristic columnar structure is absent, and the metal is similar to well forged material.

Cast iron produced in centrifugal molds has superior qualities due to the condition of the free carbon which is finely dispersed throughout the metal in small colonies or groups of a granular form, separated from each other by ferrite and pearlite. The free carbon of sand-cast cast-iron occurs in large massive plates. Pardun[14] conducted extensive experiments which show that the cause of the enhanced properties of centrifugal cast-iron are due to:

"1. The partial segregation of the sulphur into a neutral zone;
2. the distribution of the phosphorus in a finer form;
3. the very uniform deposition of the graphite in a refined form similar to temper carbon; and
4. the reduction in the size of grains."

FROM a consideration of the results of experiment and of results obtained in commercial production, it is reasonable to assume that steel shells can be cast in a centrifugal machine, and that shells so cast would compete favorably with shells produced from sand castings and from worked steel. The external shape of the shell can be formed easily in a centrifugal mold, and the internal cavities for bursting charges have shapes differing slightly from paraboloids of revolution.

In Table I are gathered data which pertain to specifications for steels suitable for shell manufacture, and to results obtained with similar steels in casting practice. From this table the following properties for steels, as cast, can be assumed as average:

FOR COMMON STEEL SHELL

Ultimate Strength	75,000 lbs./in.²
Elastic Limit	37,500 lbs./in.²

It has been shown that an increase of from 25 per cent to 100 per cent can be obtained in the physical properties of metals cast centrifugally over the same metals cast in sand. Let it be assumed that the physical properties noted above as average can be increased 50 per cent by casting the metal centrifugally. The metal would have the following properties:

Ultimate Strength	112,500 lbs./in.²
Elastic Limit	56,250 lbs./in.²

Further desirable changes in physical properties of the centrifugal castings would result from heat treatment, or, as will be explained later, from a piercing operation, which would not only conform the paraboloidal cavity to prevalent designs, but would also produce some refinement of the metal. Electrical methods for melting steel can be used for casting with a centrifugal machine. Experience has shown that electric steel has higher physical properties and is more responsive to heat treatment than open-hearth steel. For low carbon steels there is a 15.5 per cent increase in the ultimate strength and a 11.3 per cent decrease in elongation, for electric steel as compared with open-hearth steel of approximately the same composition.[15] Thus, the use of electrical melting would make possible further increases in the properties of steels cast centrifugally over those sand-cast or ingot-cast.

THE high-explosive shell used in modern field and sea-coast guns is an elongated hollow projectile made of cast or forged steel. During the World War many shells in this country were cast from semi-steel. The use of very high explosives for the bursting charges of projectiles has made it necessary for the walls to have greater strength than that possessed by cast-iron, which is now used for practice shells only.

The high-explosive shell is of major importance in modern defense and methods for its speedy and efficient production are of constant interest. It is the opinion of the writer that the centrifugal casting process has been developed to the point where it can compete with customary methods of shell casting and forging and consequently

[11]Hurst, J. E., Casts Large Pipe Centrifugally (Aug. 15, 1927). *The Foundry*, vol. 55, pp. 649-652.

[12]Anony. Centrifugal Castings, (Mar. 18, 1921). *Engineering*, vol. 111, pp. 311-312.

[13]Cammen, Leon, Chromium Alloy Steel Cast Centrifugally, (Sept. 14 1922). *The Iron Age*, vol. 110, p. 655.

[14]Pardun, Carl,— *Ueber die wissenschaftlichen Grundlagen des Schleudergusses*, (The Scientific Principles of Centrifugal Casting), (1924), Stahl and Eisen, vol. 44, pp. 905-911; 1044-1048; 1200-1208. English extracts, *The Foundry Trade Journal*, vol. 30, pp. 295-297; and 483-485.

[15]Lyon, D. A., Keeney, R. M., and Cullen, J. F., The Electric Furnace in Metallurgical Work, (1914) Bureau of Mines Bulletin 77. See also Boyleston, H. M., An Introduction to the Metallurgy of Iron and Steel, (John Wiley and Sons, 1928), p. 320, and Camp, J. M., and Francis, C. B., The Making, Shaping, and Treating of Steel, (Carnegie Steel Co., Fourth Edition 1925), p. 400.

TABLE I.
Properties of Steels Suitable for Shell Manufacture.

DESIGNATION AND FORM	CHEMICAL COMPOSITION								PHYSICAL PROPERTIES				
	C	Mn	P	S	Si	Ni	Cr	Cu	Ultimate Strength	Elastic Limit	Yield Point	Elongation	Reduction of Area
	%	%	%	%	%	%	%	%	Lbs. per sq. inch	Lbs. per sq. inch	Lbs. per sq. inch	%	%
W. D. 1045, Carbon Steel (a, d)	0.40–0.50	0.50–0.80	0.045	0.050	0.15–0.35				70,000–80,000	35,000–40,000		20–16	20–33
W. D. 1050, Carbon Steel (a, d)	0.45–0.55	0.50–0.80	0.045	0.050	0.15–0.35				70,000–80,000	35,000–40,000		20–16	20–33
W. D. 1055, Carbon Steel (a, d)	0.50–0.60	0.40–0.70	0.045	0.050	0.15–0.35				70,000–80,000	35,000–40,000		20–16	20–33
W. D. 1065, Carbon Steel, (a, d, p)	0.60–0.70	0.40–0.70	0.040	0.050	0.15–0.35				80,000	45,000		25	45
Common Steel Shell, under 8 in., ingot quality annealed (c)	0.45–0.55	0.60–0.80	0.040	0.045	0.35	Not over 0.50	Not over 0.30	Not over 0.25	75,000	37,500		21*	
quenched and drawn									100,000–90,000	60,000–50,000		15* 17*	
Common Steel Shell, 8 in. and larger (c) annealed	0.50–0.60	0.60–0.80	0.040	0.045	0.35	Not over 0.50	Not over 0.30	Not over 0.25	75,000	37,500		21*	
quenched and drawn									90,000–100,000	50,000–60,000		17* 15*	
W. D. 3250, Nickel-Chrome Steel (a, d, p)	0.45–0.55	0.30–0.60	0.040	0.040	0.15–0.35	1.50–2.00	0.90–1.25		170,000	140,000		12	35
Steel Castings, Annealed (m)	0.55								92,500	43,000		10.2	
Steel Castings, Heat Treated (m)	0.55								114,000	65,000		9.9	
Typical Group of Steel Castings (k) untreated, cooled quickly	0.40–0.60								84,000		41,500	12	15
untreated, cooled slowly									80,500		40,500	22	26.5
Steel Castings (e), unannealed annealed	0.53								90,121 106,415			2.35 9.80	
Steel Castings (e), unannealed annealed	0.37								85,540 82,228			8.20 21.80	
Steel Castings, Hard (f, g)	0.40	0.40–0.80	0.07	0.05					85,000		38,250	15*	20
Electric Steel Castings (m), untreated	0.46								102,740		66,480	3*	4.9
Electric Steel Castings (m), air cooled from Ac3	0.46								104,270		72,860	18*	27.1
Steel Castings, annealed (h)	0.42	0.73			0.46				82,100	45,990		8.41*	9.79
Steel Castings, annealed (h)	0.44	0.59			0.38				76,170	42,990		14.64*	15.11
Steel Castings, annealed (h)	0.48	0.71			0.42				76,730	42,750		12.05*	15.81
Steel Castings, annealed (h)	0.47	0.73			0.56				79,590	44,020		10.94*	11.49
Steel Castings, annealed (h)	0.43	0.65			0.46				73,200	40,200		12.5*	16.4
Hard, Resistant Castings (m)	0.50–0.70	0.60–0.80			0.35				71,000–100,000		40,000		
Acid open-hearth Casting Steel (n), 2-ton ingot, as cast	0.49	0.63	0.06	0.02	0.28				94,600			5.5	
Acid open-hearth or Stock converter shell steel, no treatment (o)	0.55	0.40–1.00	0.40	0.40	0.30	0.50		0.10	78,000–110,000		43,000	20*	

*Gage length 2 inches.
(a) U. S. Army Specifications No. 57-107A, July 1927. "Steel Bars, Carbon and Alloy".
(b) American Society for Testing Materials, Standards-1927, part I; page 179. Standard A18-27.
(c) U. S. Army, Ordnance Department Metal Specifications No. 57-104-1, Apr. 21, 1924. "Cast Steel Ingots and Steel, Rolled or Forged, for U. S. Common Steel Shell and Shrapnel."
(d) Ordnance Deparment Document No. 2050, Nov. 18, 1924. "Notes on the Selection and use of Metals in Ordnance Design."
(e) "Mechanical Engineering Pocketbook", by William Kent. (1916) Page 490, Steel Castings.
(f) American Society for Testing Materials, Standards-1927, part I; page 174. Standard A17-21.
(g) "Materials of Construction," by H. E. Pulver. (1922) page 244.
(h) "The Steel Foundry," by John Howe Hall. (1914) page 245.
(k) "Principles of Metallurgy of Ferrous Metals," by Leon Cammen. (1928) page 184.
(m) "Metallography-The Metals and Common Alloys," by Samuel L. Hoyt. (1921) pp. 221, 222, 223, 224.
(n) "Heat Treatment of Soft and Medium Steels," by Federico Giolitti. (1921) page 267.
(o) "High Explosive Shells," American Machinist Reprint 1915, page 9.
(p) "Textbook of Ordnance and Gunnery," by Lieut. Col. Earl McFarland. (1929) page 111.

should receive the attention of those charged with the control of design and production.

During the World War high-explosive shells were made from forgings, castings, and rolled bar-stock. Several methods were used for fashioning the material into the shell ready for loading, and these are illustrated graphically and comparatively in Fig. 2.[16] In the case of those blanks in which the cavity and nose were formed by forging, one that. . . ." Weights[18] furnished with descriptions of the manufacture of the forgings for British 4.5-inch howitzer shells, show that the discard from the cast ingot was 40 per cent and that only 33 per cent of the ingot was contained in the finished shell. Another author[19] who refers to British 4.5-inch, 6-inch and 60-pounder shells, places the discard at 20 per cent. In a comprehensive description of the steel-making process published by the Carnegie Steel

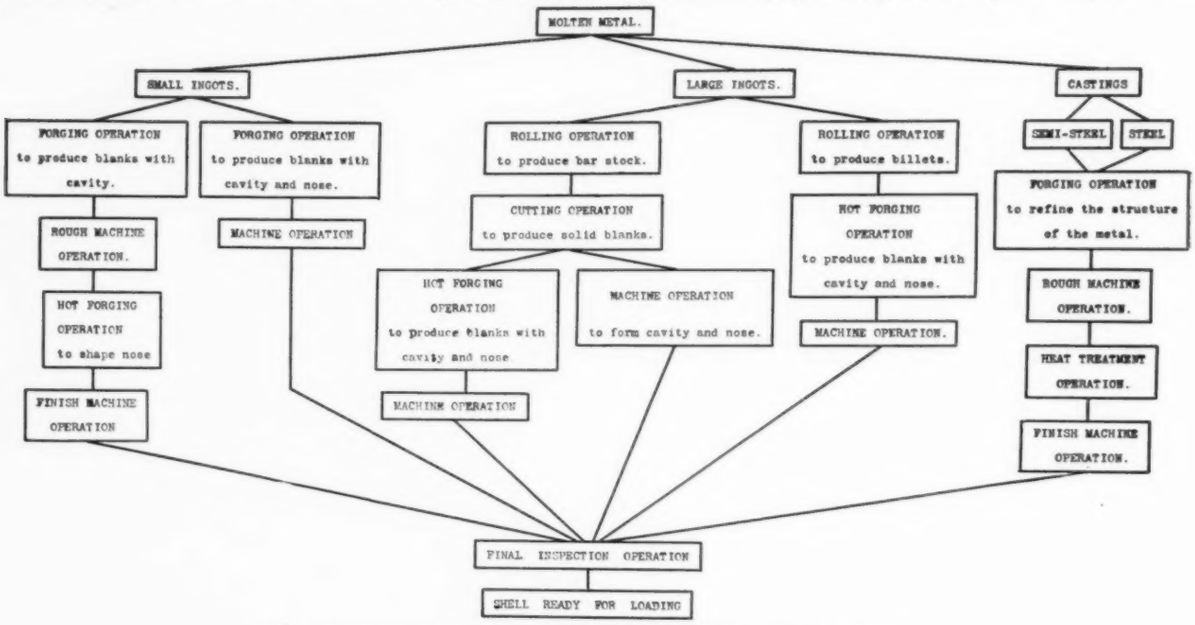
MOLTEN METAL.
SMALL INGOTS.
LARGE INGOTS.
CASTINGS
FORGING OPERATION to produce blanks with cavity.
FORGING OPERATION to produce blanks with cavity and nose.
ROLLING OPERATION to produce bar stock.
ROLLING OPERATION to produce billets.
SEMI-STEEL
STEEL
FORGING OPERATION to refine the structure of the metal.
ROUGH MACHINE OPERATION.
MACHINE OPERATION
CUTTING OPERATION to produce solid blanks.
HOT FORGING OPERATION to produce blanks with cavity and nose.
MACHINE OPERATION to form cavity and nose.
HOT FORGING OPERATION to produce blanks with cavity and nose.
MACHINE OPERATION.
ROUGH MACHINE OPERATION.
HOT FORGING OPERATION to shape nose
HEAT TREATMENT OPERATION.
FINISH MACHINE OPERATION
MACHINE OPERATION
FINISH MACHINE OPERATION.
FINAL INSPECTION OPERATION
SHELL READY FOR LOADING

Fig. 2. General Outline of Methods for Producing Shell Bodies.

or more heatings of the blank were required and in the case of the shells in which the cavity and nose were machined from bar stock, there was a considerable quantity of metal which had to be removed by a long machining process.

Table II has been constructed from information which shows in a general way the relationship between the finished shell and the amount of metal melted for that shell. Almost all of the data were published prior to the participation of the United States in the World War and has to do with the various methods of manufacture used by American and Canadian manufacturers for European orders. Except for minor developments in technology since 1916, the methods are practically those used in the manufacture of shells for United States artillery. The information shows that less than 50 per cent of the metal melted is contained in the finished shell.

United States Army Ordnance Department Metal Specifications[17] provide "Sufficient discard shall be taken from each ingot to insure freedom from injurious piping and undue segregation. Such discard, in terms of the total ingot weight, shall not be less than 20 per cent from the top and not less than 4 per cent from the bottom except Company[20], it is stated that the discard on ingots for circular shapes is never less than 25 per cent. From these sources, and others, it appears that the amount of discard averages about 30 per cent.

The amount of metal included in the discard in the methods of manufacture noted above and the amount of excess metal required for proper machining represent ineconomies which should act as incentives for investigations of the centrifugal casting process as a means for manufacturing high-explosive shells. The process offers numerous possibilities, and it is the opinion of the author that sufficient data exist to show that economies of manufacture would result from the use of the process without any reduction of requirements below those necessary for safety.

Castings of shells by this process can be made in molds with the nose of the projectile cast down, so that the shape of the casting will have the general outside shape of the finished projectile. Rotation of the metal about either a vertical axis or an inclined axis results in an interior cavity which approaches very nearly to that required in shells. Shells made in this manner would require no more machining than do ordinary cast shells such as illustrated by Tschappat,[21] and it is not likely that they would re-

[16]This figure is constructed from information compiled from the following sources:
The Manufacture of Artillery Ammunition, by Members of the Editorial Staff of *The American Machinist*. (McGraw-Hill, 1917).
Tschappat, Lt.-Col. W. H., Text-Book of Ordnance and Gunnery, (John Wiley and Sons, 1917).
Suverkrop, E. A., The Manufacture of Semi-Steel Shells, (May 29, 1919), *Amer. Mach.* vol. 50, pp. 1041-1043.
Ordnance Department drawings 75-20-41, 75-4-25, and 75-4-36 for 155-mm. Common Steel Shell.

[17]Specifications 57-0, (Feb. 13, 1924); Specifications 57-104-1, (April 21, 1924); and Specifications 57-104-2, (Dec. 18, 1924).

[18]Alford, L. P., and others, The Manufacture of Artillery Ammunition, (McGraw-Hill, 1917), p. 236 and following pp.

[19]Swabey, Capt. H. W. B., and Genders, R., The Manufacture of Shells in Canada during the War 1914-1918, (1921), *Journal, Iron and Steel Institute*, vol. 104, pp. 229-245.

[20]Camp, J. M., and Francis, C. B., The Making, Shaping, and Treating of Steel, (Carnegie Steel Co., Fourth Edition 1925), p. 400.

[21]Tschappat, Lt. Col. W. H. Text-Book of Ordnance and Gunnery (John Wiley and Sons, 1917).
See also. Suverkrop, E. A., The Manufacture of Semi-Steel Shells, (May 29, 1919) *Amer. Mach.* vol. 50, pp. 1041-1043.

quire any more machining of the cavity than does the customary forging. Of course the centrifugal product would require considerably less machine work than the product machined entirely from rolled bar stock. The centrifugal process does away with the need for the 20 per cent to 40 per cent discard.

THE dotted lines in Figs. 3, 4, and 5 show the outlines of three common projectiles, the 75-millimeter common steel shell, the 14-inch common steel shell, and the 16-inch armor-piercing projectile. The full lines in these figures represent the longitudinal cross-sections of the calculated centrifugal paraboloids of revolution which would be formed about either a vertical or an inclined axis. The speeds noted are for rotation about a vertical axis. The speed decreases as the axis of rotation is inclined to the vertical. Since the calculated speeds are low, the vertical is the best position for casting shells.

The formula describing the motion of the metal rotated about an axis contains three variables, two of which are independent. The dimensions of the shell cavity are set by the designer, and the speed of revolution for casting is determined by these dimensions. The drawings show that the centrifugal paraboloids conform only roughly to the shell cavities illustrated. Shell cavities could be made to conform to paraboloid cavities in two ways; first, the interior design of the shell could be changed without loss of necessary strength in the shell walls, and without changing the capacity of the cavity; second, the cavity

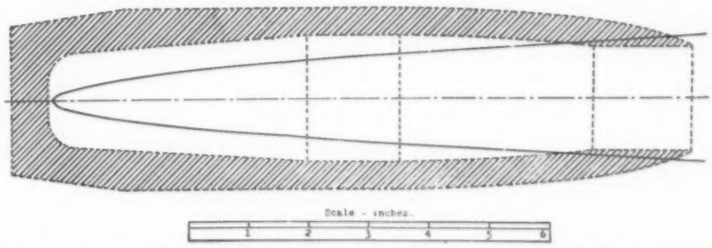

Fig. 3. 75-mm. Common Steel Shell. Parabola, $y = 126x^2$; Speed 860 r.p.m.

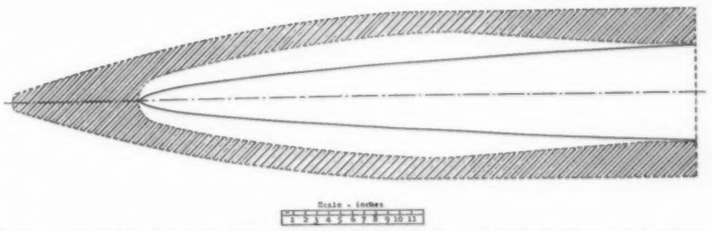

Fig. 4. 14-inch Common Steel Shell. Parabola, $y = 35.25x^2$; Speed, 455 r.p.m.

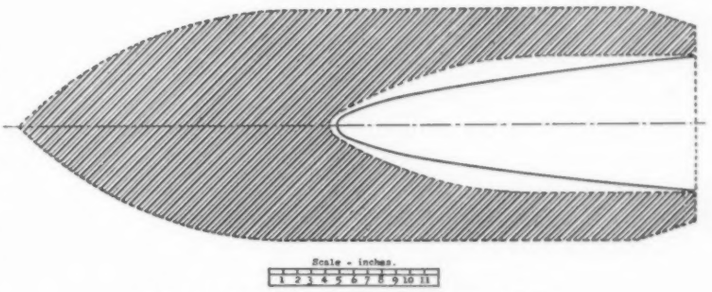

Fig. 5. 16-inch Armor-Piercing Projectile. Parabola, $y = 14.18x^2$; Speed, 288 r.p.m.

TABLE II.
Relation of Ingot Weight to Weight of Finished Shell.

SHELL—CALIBER AND TYPE	MANUFACTURE OF SHELL BLANK	Weight of Ingot	Discard from Ingot	Weight of Shell Blank	Weight of Finished Body	METAL MACHINED		FINISHED BODY	
						Per Cent on Blank Basis	Weight	Per Cent of Ingot	Per Cent of Shell Blank
		Lbs.	%	Lbs.	Lbs.	%	Lbs.	%	%
4.5 in. British	Forged and pierced (h)	78	40	46	26	45	42	33	55
18 lb. British	Drilled solid forging (a)	36*	25*	27	14(b)	48	13	39*	52
18 lb. British	Forged and pierced (c)	36*	25*	27	14(b)	48	13	39*	52
60 lb. British	Forged and pierced (c)	116*	25*	87	50(d)	42.5	37	43*	57.5
6 in. H. E. British	Forged and pierced (c)	210*	25*	155	87(e)	45	68	41*	55
8 in. H. E. British	Forged and pierced (c)	366*	25*	275	173(f)	37	102	47*	63
9.2 in. H. E. British	Forged and pierced (c)	520*	25*	390	244(g)	37	146	47*	63
1 lb. Russian	Machined bar stock (i)			2	1	50	1		50
3 in. Russian	Machined bar stock (j)			24	10	58	14		42
75 mm. Mark IV, Common Steel	Forged, pierced and nosed (k)	32*	25*	24	11	54	13	34*	46

*These values based on a 25% discard from the ingot. However, the discard may be as much as 40%.
(a) The Manufacture of Artillery Ammunition, by Members of the Editorial Staff of the American Machinist. (McGraw-Hill, 1917), p. 251.
(b) Idem, p. 744.
(c) Swabey, Capt. H. W. B., and Genders, R., The Manufacture of Shells in Canada during the War, 1914-1918. J. Iron and Steel Inst. Vol. 104, pp. 229-245. (1921).
(d) The Manufacture of Artillery Ammunition, by members of the Editorial Staff of the American Machinist. (McGraw-Hill, 1917), p. 746.
(e) Idem, p. 747.
(f) Idem, p. 748.
(g) Idem, p. 749.
(h) Idem, p. 236.
(i) Idem, p. 412.
(j) Idem, p. 442.
(k) Ordnance Department Drawing 75-2-180; and drawing 75-20-40. Shell for 75-mm, Common Steel, Mark IV.

design could be left unchanged, and the centrifugal casting could be pierced hot with a steel mandril, in the same way that forgings are pierced at present. Piercing would give the cavity its proper shape and at the same time would refine the metal of the casting.

The speeds of revolution calculated to produce the cavities required in the shells illustrated, are too low for successful casting of the metal. A slowly revolving mold will only momentarily "pick up" the metal, and the centrifugal force will not be sufficient to hold the molten metal against the walls of the mold. Favorable speeds for the production of centrifugal castings about vertical and inclined axes are given by Wood,[22] as follows:

Favorable Speeds of Revolution for Various Diameters

Diameter	Speed
4 inches	1183 r. p. m.
6 inches	967 r. p. m.
8 inches	837 r. p. m.
10 inches	748 r. p. m.
12 inches	684 r. p. m.
15 inches	611 r. p. m.
18 inches	558 r. p. m.

The author can offer no solution for the problem of rotation speed during casting. It is possible that coöperation between the shell designer and the centrifugal metallurgist in a series of experiments would result in a successful method for casting steel shells by the centrifugal process.

Research work on the centrifugal casting of projectiles is required before definite conclusions concerning the possibilities can be drawn. Problems other than speed of rotation are the design of a casting machine readily adaptable to large scale production, involving such details as (1) the method of pouring the correct amount of metal into the mold; (2) the mold material; (3) the lining of the mold; (4) the starting speed of rotation during pouring and the ultimate speed; (5) the time of rotation; (6) the removal of the casting from the mold. A series of organized experiments would solve such problems and would show whether or not centrifugally-cast shells could meet metallurgical and physical requirements.

Summary

1. Metals have been cast centrifugally for over a century.
2. Centrifugal casting is important commercially in the manufacture of cast-iron pipe, cast-iron piston rings, bronze worm-gear blanks, thin metal tubing, steel billets for rolling, etc.
3. Results in commercial practice show that centrifugally cast metals are superior to statically cast metals, so that if shells could be cast centrifugally, they would probably possess the physical and metallurgical properties required.
4. The interior free surface of a metal cast centrifugally about a vertical axis or an inclined axis is a paraboloid of revolution, the dimensions of which depend upon the axial angle and the speed of rotation.
5. The cavities for bursting charges of modern projectiles have shapes approaching paraboloids of revolution.
6. Calculations show that the speeds of rotation for casting three common projectiles are lower than those recommended for success.
7. Speed of rotation is one of several problems involved in the centrifugal casting of projectiles. Research would solve these problems and demonstrate the possibility or impossibility of using the method.

[22]Wood, R. F., Uses for Centrifugal Casting Calculations, (Dec. 1925), *The Metal Industry*, New York, vol. 23, pp. 491-492.

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Gain in Infantry Marksmanship

A TWENTY per cent increase in four years of the rifle marksmanship proficiency of Infantry regiments—in spite of a 58 per cent reduction in ammunition allowance—is reported by the Chief of Infantry. In 1924, sixty-four per cent of all infantrymen in infantry regiments armed with the rifle were qualified marksmen, whereas, in 1928, eighty-four per cent were entitled to wear a badge denoting skill in shooting the rifle.

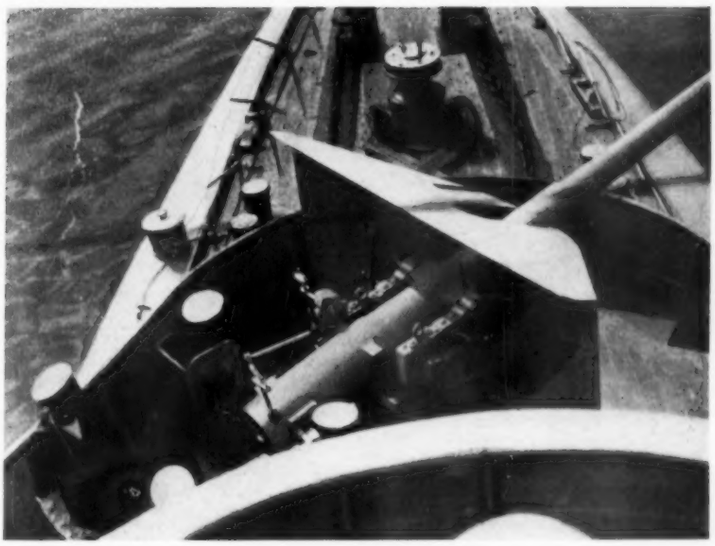
The marked progress is considered to have been due primarily to the universal use of the small-bore rifle in teaching men how to shoot and to stringent regulations requiring every available man to fire the marksmanship course. The use of the caliber .22 rifle in testing the thoroughness of preliminary instruction has been instrumental in pointing out the faults of the riflemen and has allowed corrective measures to be applied prior to their using the full-power service cartridge. The regulations requiring every man to fire, unless excused for cause, has decreased the number not firing the course from 9,000 in 1924 to 4,200 in 1928.

A comparison of the records of 1924 and 1928 shows that 89.5 per cent of the infantrymen who fired four years ago qualified in marksmanship, while in 1928, 93.7 per cent obtained qualifying scores.

Ordnance in China

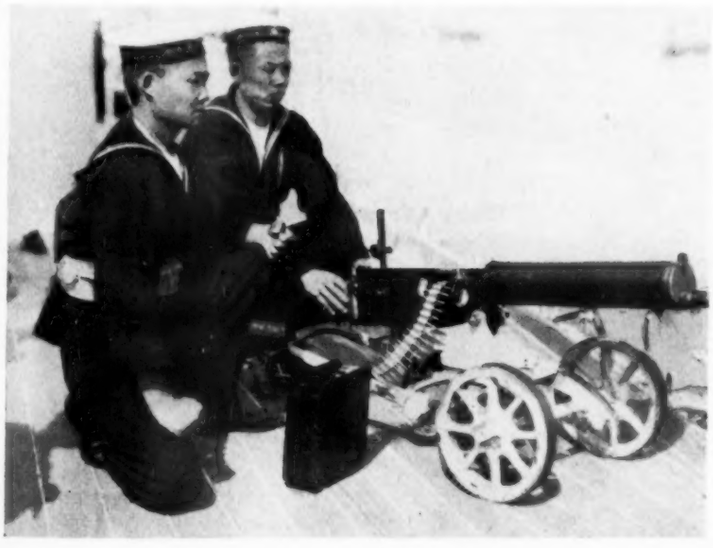
Aboard a Chinese Police Boat.

Gunner aboard a Canton, China, police boat about to touch off an ancient cannon still carried by these craft. Such guns, which are far more numerous in the Canton Delta than their up-to-date descendants, are still quite serviceable in that they strike terror in the hearts of pirates and bandits upon whom they are trained.



With the Chinese Navy in Canton.

Elaborate maneuvers marked the recent war games of the Chinese Navy in the Canton Delta. Here is shown a bow-chaser gun on the S. S. Feining (Flying Eagle), one of the cruisers of the fleet which participated in the maneuvers.



Machine Gun Practice in China.

Members of the crew of the S. S. Feining operating a machine gun during the practice exercises incident to the recent maneuvers of the Chinese Navy in the Canton Delta.

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Month by Month

The Latest Christie Tank

MR. WALTER CHRISTIE, whose efforts during the past decade to produce the combined wheel and track type of ordnance vehicle are well known, has demonstrated recently a new model tank embodying modifications of what we know as the Christie principle. From the rotogravures and news reels we learn that the new vehicle in preliminary demonstrations has shown that it is capable of exceptionally high speeds on the roads and across country. We understand that the Ordnance Department desires to purchase one of these vehicles and submit it to proving ground tests similar in character to those recently undergone by the new light tank, T1 E1, to be followed by the usual tests by the using services.

Mechanization of armies, in our judgment, is the outstanding problem of present day military development. It demands and deserves the best possible thought and effort of all concerned, not only in the technical development of machines but in the determination and employment of the tactical organization and principles necessary for the proper utilization of a mechanized force. Much of the latter, of course, will depend upon the weapons--vehicles and armament—determined upon for such use. Obviously, it is in the interests of the national defense to obtain the best possible types of vehicles. If those types prove to be of Mr. Christie's design, notwithstanding somewhat abortive attempts in the past, then that design will be given complete, open-minded tests. If that design meets all military requirements then by all means it should be incorporated in our mechanization plans. Such we know to be the attitude of our ordnance authorities.

However, there is capable technical opinion which, in the light of past experience, believes that a dual purpose combat vehicle is impracticable. Engineers of this leaning say that mile-a-minute speed on wheels on macadam is incompatible with sure, relatively fast travel on tracks across country; that an automotive vehicle can do efficiently, reliably and consistently one or the other but not both. The casual observer may say that the better logic seems to be on their side. The end to be attained is not de luxe travel on the roads—battle fields are always open country. The desideratum is a dependable, sturdy vehicle whose element is rough terrain built to take, day in and day out, the ups and downs of the Round Tops or Wilderness. How that vehicle—whether under its own power or not—gets to its place of deployment and action is secondary provided it gets there quickly and on time. However, if the latest Christie vehicle can do what is claimed for it then one of the basic requirements of mechanization is met.

Mechanization of our Army demands that all reasonable steps in its evolution be undertaken with an open mind remembering always that battles are fought not on the fairways but in the rough and that they are not postponed on account of weather. The mechanical brute that does its job must thrive on obstacles and be ready to meet all comers under all circumstances. Whether mechanical development has yet progressed to the stage that it can combine in one unit a trotting horse and dray animal remains to be seen. Meanwhile judgment will be withheld until the new Christie is given a chance to take the gruelling hurdles his brethren of Army design have already cleared.

Reserve Officer Camps

THE usual spring and summer training camps for officers of the Ordnance Reserve Corps for 1929 have come and gone. Approximately 400 ordnance officers, or roughly, 16 per cent of the reserve personnel on active status, were trained. As in the past, the larger camps were held at the Rock Island Arsenal, and at the Aberdeen Proving Ground, while at practically every ordnance establishment courses were conducted at various times for smaller groups. The degree of interest displayed by the student officers was highly satisfactory and the courses of instruction, the plans for conducting the camps at the several establishments, and coöperation of the regular personnel was all that could be desired.

Since the largest camps were conducted at Aberdeen and Rock Island, it may not be inappropriate to single out for especial commendation Maj. R. H. Somers and Lieut. G. T. Rowland, directors of training at the respective camps. Both are exceptional officers whose knowledge, experience and personality make success assured. Indeed, they are typical of officers of the Department.

It is a most encouraging sign, we believe, to have officers of the reserve corps attend training camps in even such limited numbers. While the percentage may not appear high, regulations governing camp attendance and the possibility of reserve officers being unable to attend because of business conditions suggest the augury that the Ordnance Reserve is in a high state of efficiency, interest is keen and the caliber of men holding reserve commissions is creditable both to them and the Department.

It should be a cause of great satisfaction to all our people to know that so highly specialized a branch as ordnance is has for its peace-time administration a group of especially qualified regular officers and for its war-time auxiliary a competent, active and well-informed organization of reservists.

It is to be hoped that sufficient funds will be appropriated for the training of a larger number of reservists of the commissioned grades, and for active training of enlisted reservists thus rounding out a comprehensive active duty program for the civilian component of the Army.

Shall We Draft Labor in War?

PROPONENTS of "draft everything in war" would do well to think seriously about some of the complex, practical questions that must be answered and answered satisfactorily before their rosy hued scheme can be attained. One point worthy of serious thought is that connected with the draft of labor. Advocates of the universal draft seem to overlook the very practical outcome of a draft of labor, namely that every laborer drafted could, and in all probability would, become the recipient of a disability and old age government pension. Having served the government drafted labor would be entitled to the same consideration extended veterans since time immemorial. Is it an exaggeration then to visualize the exorbitant pension rolls of war thus managed?

There are, of course, weighty constitutional questions that affect most deeply the conscription of labor in time of war. There is the fundamental guarantee of freedom of contract; there is the basic right to protection against involuntary servitude. In addition, there are other practical considerations, first and foremost of which is the principle that a war is lost at the start unless there is the voluntary, spontaneous will of all the people to undergo hardship and sacrifice, to do instantly and voluntarily whatever is required. A people driven to war by their own authorities are not a people at war and sooner or later an unpopular cause will fail. We have no intention at this time to enter into a lengthy discussion of these basic tenets. But the question of pensions for drafted labor is, we believe, a phase of the matter seldom broached by either side. Yet it is a very practical consideration. If labor is to be drafted in another world war then we had better prepare for pension rolls in comparison with which the total cost of all pensions to date and even of all wars will dwindle to insignificance creating a condition in which the remedy may be worse than the cure.

Our Eleventh Annual Meeting

AS already announced, the eleventh annual meeting of the Army Ordnance Association will be the occasion for a gathering of members and guests of two important nation-wide organizations, the National Aeronautic Association and the National Metal Trades Association. Articles descriptive of the aims and purposes of both associations are published in this issue of our journal.

The place of aircraft in national defense has assumed proportions of dominant command. Not only is commercial aviation making gigantic strides, but military aviation has already earned for itself a position of first rank in tactical employment. How greatly the conduct of war has been affected by the airplane only another conflict will determine. To us it seems that the day is not far distant when the airplane will displace entirely the larger calibered guns. That in itself is a revolutionary development. The reason for it seems obvious. The only reason for the large gun is to deliver its projectile at great distances. At the time of its development there was no other medium for carrying a great mass of demolishing power. Today the airplane can deliver any quantity of explosive power limited only by its cruising radius and weight-carrying capacity. Recent record flights using refueling planes have their important relation to military aeronautics in an especial way in that heavy bombs formerly difficult to take off can now be launched with a lightened gasoline load, the required fuel being received later in the air. Likewise there is the important question of antiaircraft so closely allied to aircraft progress. These and other problems so intimately associated with ordnance and the national defense place particular importance upon our joint meeting. There is every assurance that the program of demonstrations at the meeting will include an instructive and spectacular exhibition of both aircraft and antiaircraft developments.

Of the National Metal Trades Association, which also will join with us at the meeting, much can be said as to the close connection of that organization to munitions preparedness. Battles are no longer fought with fire brands and pikes. The metals, from the lowly iron and lead to silver and platinum, are the sine qua non of munitions defense. In our machine age in war and peace the metals are essential; without them neither peace-time manufacture nor war-time production could continue—the machines and appliances of everyday life are entirely dependent upon them in some form or other. Ordnance—and therefore munitions—require the metals in unlimited quantities. Consequently an organization devoted to the advancement of the metals industries has a very definite place in our general scheme of industrial preparedness. The presence of such an organization at our gathering will serve as a public manifestation of the close contact and coöperation which should and does exist between our defense agencies and the metal trades.

Members of our Association and our guests have received invitations and complete preliminary information concerning the meeting.

Colonel Robbins is Right

SPEAKING recently to the members of the Reserve Officers' Association in annual convention, Col. Chas. Burton Robbins, former Assistant Secretary of War, registered an unequivocal plea for Army mechanization for which all friends of munitions preparedness are grateful. He said, in part:

"This year England is spending ten million dollars on new equipment for mechanization. I tried my best to get a clause in the budget for this year giving us five hundred thousand in cash and a contract authorization of a million and a half for these new tanks. That would be enough to build a hundred tanks and arm the Regular Army with this new Cunningham tank which will go better than twenty miles an hour carrying two men and armed with a one pounder and machine gun.

"Congress didn't give it to us. That is something that this body of men can help along—educating Congress and educating the people to the necessity of mechanization of our Regular Army first. If we are going to have a little Regular Army of 118,000 men, for God's sake let's have it the best that can be had in the world, anyway, and provided with the most modern, up-to-date and efficient weapons so that in time of war they can double up their capacity over that of other nations instead of having men plodding along in the dust in the old style of marching when the enemy is moving forty or fifty miles an hour in armored cars and transporting troops from one place to another."

Our Program of Military Rearmament

An Editorial

MR. CROWELL, the president of our Association, sounds a very timely note in his article published in this issue of ARMY ORDNANCE as to matters of munitions preparedness. Certainly the opinion of no other individual in private life is worthy of more consideration than his. Having served with distinction as Assistant Secretary of War and Director of Munitions during the World War, and having displayed an unusual interest in industrial preparedness continuously since that time, there is added reason to lend an attentive ear to whatever he says on the subject. That he has chosen an opportune topic is obvious.

It is an aphorism to say that if we are to have, as we make every pretense of having, a system of national defense worthy of the name, efficiency demands that every possible reasonable expedient be utilized. As Mr. Crowell points out, one of the weak spots of our system is the dearth of new fighting equipment in the Army. One might almost say that we are overdeveloped in new types were it not that development has progressed only in proportion with demand. The disparity arises in the unbalanced condition caused by continual development and practically no production, the result of which is an Army equipped with old weapons although proved designs of modern types are available. The result? A military force which is not manned with newer equipment and consequently an army which is not as efficiently prepared for its purpose as it should be.

FAR-SEEING friends of preparedness have visualized this condition for some time. They have watched while programs were agreed upon allotting for a period of years definite sums for the production of newer types. A five-year program was adopted for the Air Corps and a ten-year program for Ordnance. Modest though the Ordnance program was it has fallen most decidedly flat for the unescapable reason that the money has not been forthcoming. The Ordnance ten-year program after several years' delay now becomes almost a twenty-year program. If the subject is dilly-dallied with much longer it will be a thirty-year program and so on simply to provide a very few organizations of the Army with new ordnance. Under the ten-year program so much money was to be allotted regularly each year. But of the first year money only a portion of the program requirement was appropriated leaving a deficit to be carried over into the second year. For the second year only a portion of the agreed sum was made available leaving a deficit for the second year plus the deficit for the first year, and so on and on with deficits increasing and the program fast losing ground. Add to this condition similar lethargy about appropriations for other vital expansions of the Army and ask, What is the matter with our people since they alone are responsible? Are they through with wars and reasonable preparation for them? Then do away with Army and Navy altogether. Are they in favor of an out-of-date Army equipped with antique weapons and untrained in the use of modern armament? Then heaven delay the day when our Army so equipped meets a foe who has not tossed opportunity to the wind. Huge treasury balances of past years will then be of little avail. Disproportionate sums spent on national fads and fancies will not count for much; indeed there will be no more striking through pathetic example of the old adage, penny wise and pound foolish.

IT is a strange commentary on life and particularly life in America that when the war clouds are blown away we are so forgetful of past lessons learned at tremendous sacrifice of blood and property. We are content to remember the glories of our victories and forget the probabilities of defeat. We lumber along in a self-sufficient way passing by opportunities that cost little, willing to take our chances on emergencies that cost most—far too much. The solution of this particular problem is so simple, so relatively inexpensive, so necessary for the efficiency of our Army that one is at a loss to explain its cause, our lethargy admitted. When a man of the experience and judgment of Mr. Crowell calls attention to the situation as he has done, the people would do well and wisely to heed and follow his advice. Who knows but that our Army today equipped with only a small quantity of new ordnance matériel—only enough for instruction for the several components of the service—may mean victory or defeat in a day when time and discussion and even money may not be so readily available. And this is not a preachment for war but a guarantee of peace—that flitful thing that must be guarded carefully lest it slip from our grasp though we will to retain it.

The task undertaken at the direction of the President "to reconsider our whole Army program to see what services and other outlays have become obsolete through advancement of science and war methods and what development programs can be well spread over longer periods in view of the general world outlook" can perform a very vital service since its avowed aim is constructive and not destructive. Possibly there are instances where further economy can be had. We doubt however that any material savings can be effected unless very radical inroads are made into our present system of national defense.

Where then will the pruning knife strike? Indeed if there is to be a squeeze the savings and hundreds times more should be spent on new equipment to replace World War weapons with modern munitions. But the defense services—military and naval—are always the first to face the music. Trim, trim, trim, until the repetition of the treatment has deadened the hurt and if war comes again do just as we have always done—ride the Army because its equipment is obsolete, because it hasn't an emergency supply of serviceable ammunition, because it couldn't stand the constant trimming and called it a day. Let us hope that the analysis to be made will bring out these facts in bold relief. If essential munitions programs are to be spread over longer periods then Mr. Crowell's admonition that we replace old guns with new (which, by the bye, was written several months before the announcement of the proposed General Staff study) may be history—and very humiliating and costly history—in the making.

Professional Notes

Use of Metal Crates for Packing Bombs

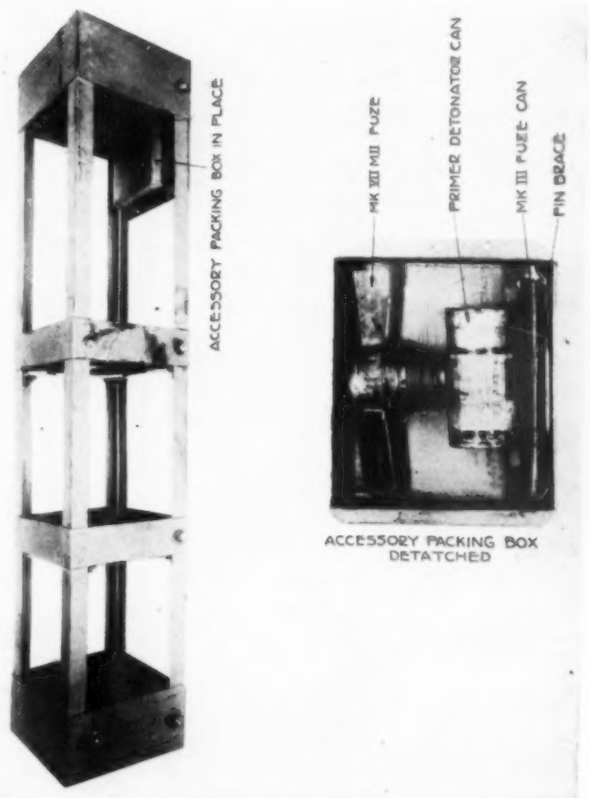
TNT and similar high explosives are packed for shipment in boxes made either of cardboard or of wood. These are relatively weak and, therefore, do not confine the explosive to any great extent. In case of fire the explosive is much more likely to burn than to detonate, giving off a fierce flame very similar to a fire from grease or oil.

However, when the material is loaded into a metal container the case is entirely different. The explosive is strongly confined and, in case of a fire which raises the temperature sufficiently to cause either ignition or detonation, detonation is much more likely to result. With shell the amount of explosive is about 10 per cent of the total weight of shell. This is sufficient to cause great damage in case of fire but the condition is not nearly as bad as is experienced in the storage of demolition bombs. The average demolition bomb contains from 45 to 55 per cent of the weight as high explosive. Therefore a ton of bombs contains approximately 1,000 pounds, while a ton of projectiles contains only about 200 pounds of explosive. For this reason loaded demolition bombs constitute, in case of fire near them, one of the greatest storage hazards of the Ordnance Department. When packed in wooden crates the resulting fire hazard is much greater than when metal crates only are used.

In the design of metal crates three different policies may be followed: (a) the use of three separate containers, one for bomb body, one for fins and one or more for auxiliary components; (b) the use of one container for body, and a second one for fins and auxiliary components; (c) one container only for bomb body, fins and auxiliary components.

From the design and manufacturing standpoint the first is much the simpler. The bomb body is a rigid object and the greater part or even all of the support may be thrown on it. The container would be, as in most commercial shipping, merely a means of preventing prominent parts from being injured from accidental blows. The fins and auxiliary components are light so that the design and manufacture of a box with sufficient strength adequately to protect them is not difficult.

The third policy is most desirable from the standpoint of the using service, in that a complete unit is shipped in one container and the delays incident to mistakes and failures in transportation will be greatly reduced. The inclusion of the fins and auxiliary components adds greatly, however, to the difficulties of the design and manufacture. Such components require adequate protection by the container, which must also carry the heavy bomb body. The difficulties are somewhat similar to what would be experienced if heavy machinery and glass bottles were packed in the same carload shipment. Satisfactory protection of the bottles would require that the machinery be packed as rigidly and strongly as the bottles themselves which increases the expense. In the same manner satisfactory protection of auxiliary components in unit shipment requires that the bomb body be packed as strongly and rigidly and hence expensively as the auxiliary components themselves in order that damage to them may not result from the weight of the bomb body.



Structural Steel Packing Crate and Accessory Packing Box for 100-lb. Demolition Bomb.

THE policy outlined under (b) above is a compromise between the two other policies in an effort to reduce manufacturing difficulties and further give unit assembly to as great an extent as possible.

In the design of a bomb crate or any other similar shipping container the difficulties of manufacture will be greatly reduced, provided a certain amount of flexibility can be allowed for in the crate. The weak point of most metal crates is in the means used to join the various members together. These may be bolts, screws, welds, etc.

During the World War one of the hardest materials to procure was lumber, the amount of which is being greatly depleted each year. On the other hand the amount of structural steel available and facilities for producing it are increasing. On the basis of cost alone the metal crate has the probable advantage at the present time. Due to the trends of availability and production this advantage should become greater with time instead of less.

The use of metal crates in the storage and shipments of loaded bombs should be a step forward from the standpoint of both safety and cost.

W. A. GIBSON,
Picatinny Arsenal.

Books

The Life of Lord Pauncefote, First Ambassador to the United States. By R. B. Mowat. Boston: Houghton Mifflin Co. 1929. $5.00.

IN spite of the strained situation between the United States and England in the unfortunate Venezuela affair, the thirteen years of Lord Pauncefote's embassy in Washington (1889-1902) marked the development of more cordial relations between the two countries. The author of this biography of a great British diplomat emphasizes the importance of Lord Pauncefote's American sojourn by devoting more than half of the book to this phase of his long career. To the American reader this will prove the more interesting portion of the biography, for therein are frank discussions of such questions as the Venezuela affair, the Bering Sea Arbitration, and the Spanish-American War. The book is well written and authoritative and a useful source of information on Anglo-American relations at the end of the nineteenth century.

Speech and Hearing. By Harvey Fletcher. New York: D. Van Nostrand Co. 1929. $5.50.

THIS is a review of the work done by the Bell Telephone Laboratories for the past fifteen years on the problem of transmission and reception of voice sounds and music as related directly to electrical and acoustical instruments. Speech and music are analysed and classified qualitatively and quantitatively.

The importance of this investigation is apparent when we stop to realize that spoken words and music can be heard at points thousands of miles from the source, or can be recorded for future reproduction, so that neither space nor time are barriers before the mechanisms of sound transmission. In this volume Doctor Fletcher has brought under one cover a wealth of detailed information quite necessary to the student and research worker in the rapidly growing field of acoustics.

Nitroglycerin and Nitroglycerin Explosives. By Phokion Naoum. Translated by E. M. Symmes. Baltimore: The Williams & Wilkins Company. $6.50.

DR. NAOUM, director of research of the Nobel Company, published his book in German in 1924. Mr. Symmes, of the Hercules Powder Company, in addition to preparing an excellent translation of this noteworthy work, has corrected a serious deficiency of the original book. While Naoum failed to cover American practices in the explosives industry, Symmes has incorporated in his translation many footnotes in which he has briefly but accurately indicated the differences between European methods of manufacture and those commonly employed in this country. Part I discusses nitroglycerin, its raw materials, details of manufacture, plant construction, and its physical, chemical, physiological and explosive properties; Part II, on homologous and related nitric esters, covers very thoroughly many explosive substances of interest, including the glycol nitrates, glycerin-sugar mixtures, etc.; Part III, is devoted to the various types of dynamites. Nitroglycerin smokeless powders are almost entirely neglected, the one short chapter on the subject discussing only the utilization of stocks of such powders left on hand after the World War. Among the numerous literature references cited, there is noted a tendency to give German references rather than the references to original articles by American authors. Only a few typographical and other errors are noted. With 469 pages, as compared with 416 pages of the original German book, the translation is nearly three times as thick as the original—a disadvantage where shelf-room is limited. Mr. Symmes is to be congratulated on doing a real service for explosives chemists and engineers in putting into English this comprehensive and up-to-date book on explosives.

England: A History of British Progress from the Early Ages to the Present Day. By Cyril E. Robinson. New York: Thomas Y. Crowell Co. 1928. $5.00.

IT is not possible in a review of this length to do full justice to this important work. Professor Robinson has succeeded admirably in making his book highly interesting and readable, an exceptional quality in a short general history.

The necessary generalization of a short history of England is enlivened by the judicious interweaving of intimate and biographical details. These not only give life to the story but tie the general theme to the men and life of the period.

The whole is written in the form which is often called the "new" history, which adds to the usual dynastic and military chronology a full discussion of the economic, commercial, scientific, religious and human factors which in their combined effect produce *history*. The parts dealing with America are well handled.

The author's hypothesis that the general character of any people or age is well expressed in its architecture, is interestingly set forth and is illustrated by plates. There are in all 63 maps and plans and 24 plates with over 800 pages of text. A detailed chronology, a complete bibliography and an index are included. Any person desiring a good understanding of all that England means in the world will be amply repaid by reading this entertaining story. May there be more histories as well written as this.

The Falls of Niagara. By Glenn C. Forrester. New York: D. Van Nostrand Co., Inc. 1928. $2.50.

THE author succeeds admirably in presenting the life and romance of Niagara Falls throughout the ages and in addition introduces the reader to the methods of interpretation of geological evidence to be found wherever the mighty forces of nature have left their traces. One cannot read this book without absorbing some of the enthusiasm of the author for his subject which in turn awakens one's interest in geological formations elsewhere. This book should be of interest to the tourist who contemplates viewing the falls again or for his first time, and it also should interest those having concern for its power, potentialities and developments and its probable future life.

Following his interpretation of the life of the falls through the various geological periods, the author outlines a suggested tour of Niagara indicating the points of geological interest referred to in the body of the book.

Radio, A Study of First Principles. By Elmer E. Burns. New York: D. Van Nostrand Co., Inc. 1928. $2.00.

THIS compact text on the principles of radio contains a very large amount of information concerning the various elements which comprise the modern radio circuits, their purpose and their theoretical operation. It is sufficiently clear and concise in presentation to serve admirably the purpose for which intended; namely, for schools, evening classes and home study. At the same time it contains a proper amount of advanced radio to indicate the subject matter for more extensive investigation. The diagrams of circuits are particularly clear and pleasing, those in which symbols are used being also shown with representations of the several different apparatus, thus making them quite complete for purposes of instruction. Reviews of the subject matter follow each chapter in the form of questions.

Receiving circuits as a whole are presented first, followed by the explanations of the individual units of which the circuits are composed, their purpose, and the theory of their operation. This method of arrangement seems quite logical and should prove to be very advantageous.

This book should be of great value to amateur radio experimenters and to those who are striving to grasp the present day atomic physics and its potentialities. It is recommended as being clear, simple and thorough.

Atmospheric Nitrogen. By Dr. Bruno Waeser. Philadelphia: P. Blackiston's Son & Co. $10.00.

THE translation of Dr. Waeser's book has greatly extended the sphere of its usefulness to the chemical industry. Volume I confines itself to a fairly thorough description of the status of the nitrogen industry in all the countries which have taken up the production of synthetic nitrogen. Volume II is devoted to a discussion of the various processes used and the relative merits of each process as nearly as can be ascertained from data which were available to the author.

No definite system has been followed in the compilation of the data: economics, statistics, processes and references are given indiscriminately which makes it rather difficult to follow any one development without constant reference to other portions of the book. It can be said, however, that the information contained therein is well worth while and that no person interested in the nitrogen industry can afford to be without these two volumes.

Living in the Twentieth Century. By Harry Elmer Barnes. Indianapolis: The Bobbs-Merrill Co. 1928. $3.50.

PROFESSOR BARNES, who is professor of historical sociology in Smith College, devotes the first third of his book to an extremely interesting and comprehensive review and estimate of all phases of present-day civilization. There are worked into this part brief historical references to the evolutions which brought about the present conditions. This largely noncontroversial section is considered the best part of his book. The ultrarapid scientific development of the last hundred years is particularly contrasted with the slower development of the social and political structure.

The author then discusses such present-day problems as democracy, war, health, and economics with particular emphasis on the sociological aspects thereof and his *liberal* solutions thereto. This is followed by a fine plea for the "new" history, which is, briefly, a history of *all* that man does and thinks rather than merely a political and military chronology. This is an intelligent and interesting discussion of the status and future of human progress from a determinist viewpoint.

Civilization: An Essay. By Clive Bell. New York: Harcourt, Brace and Company. 1928.

IT is a fairly safe assumption that few, if any, of the millions of men who laid down their lives in the World War for "Civilization" had in mind anything resembling Mr. Bell's meaning of this "expensive word." In arriving at his definition the author's analysis of what civilization does not signify is followed by a determination of the principal common characteristics of the Athenian, the Italian Renaissance, and the French eighteenth century civilizations which he deems the most outstanding among the great ages of history. From this he finds two primary qualities of civilization—reasonableness and a sense of values whence spring a host of secondary qualities. He then suggests a way to civilization that would be most alluring to the elect few, but which is unfortunately not likely to be adopted in a modern democracy. The essay is decidedly stimulating and is written in a clear and witty style.

The Elements of Crime, Psycho-Social Interpretation. By Boris Brasol. New York: Oxford University Press.

AT this time, when some states are striving to reëstablish the death penalty and others are equally as earnestly trying to abolish it, and both attempting to accomplish the same end—the reduction of crime, this book comes most opportunely. Numerous agencies are attempting in various ways to reduce the number of criminally disposed persons, many of these well intentioned organizations having no scientific foundation for their approach to the problems and being moved in large part purely by kindness of heart.

Boris Brasol in this book shows that correction can only be made by a complete understanding of the environmental influences and psychic tendencies causing the actions against social order. The cause may be quite an elusive and indistinct matter difficult to determine. The author shows the influence of the economic factor, of religion and of the family. Education and the press, and the part they play is clearly set forth, as is also the relation of crime to legislation.

The portion of this subject which has been meagerly disseminated is the approach through the psycho-physical aspect. This the author makes quite lucid and demonstrates satisfactorily that our legal and judicial systems must provide for its receiving its proper recognition in criminal proceedings. He also urges a more judicial use of expert testimony which would avoid the miscarriage of justice in jury systems especially where opposing expert witnesses tend hopelessly to befuddle both judge and jury.

Mr. Brasol is well qualified to treat of this subject due to his training under Professor Reiss of Lausanne and Professor Bertillon of Paris and because of his extended connection with criminal law in St. Petersburg and New York. This work is highly indorsed by both Professor John H. Wigmore of Northwestern University and by Dr. William A. White of Washington, D. C.

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